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UNITED STATES DEPARTMENT OF AGRICULTURE

REPORT ON
THE AGRICULTURAL EXPERIMENT
STATIONS, 1935



PREPARED BY THE
OFFICE OF EXPERIMENT STATIONS

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UNITED STATES DEPARTMENT OF AGRICULTURE

OFFICE OF EXPERIMENT STATIONS

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REPORT ON THE AGRICULTURAL EXPERIMENT STATIONS, 1935

By J. T. JARDINE and W. H. BEAL¹

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INTRODUCTION

This report, prepared in accordance with the requirement that the Secretary of Agriculture shall ascertain and report to Congress on the use made of Federal funds for the support of agricultural experiment stations in the several States and Territories, deals primarily with the use made of \$4,388,000 (\$90,000 to each State, \$15,000 to Alaska, \$28,000 to Hawaii, and \$25,000 to Puerto Rico) provided by the Hatch, Adams, Purnell, and supplementary acts for the support of the stations during the year ended June 30, 1935, but also deals with use made of funds derived from other sources and gives a general summary of the work of these stations as a whole, discusses questions of their organization, administration, personnel, research facilities, needs, trends, and public service, and reviews the progress made in coordination of the work of the Department with that of the experiment stations.

INCOME

The total income of the stations for the year ended June 30, 1935, was \$15,072,261.84, as compared with \$14,188,455.19 for the previous year, showing an increase of \$883,806.65, or 6.2 percent. Of the total income, \$4,388,000 was derived from appropriations under the

¹ With the collaboration of other members of the Office staff.

Hatch, Adams, and Purnell Acts and \$68,936 from appropriations to the Department of Agriculture for the benefit of the stations in Hawaii and Puerto Rico.

The income of the stations from all sources for the fiscal years 1934 and 1935 is shown in table 1.

TABLE 1.—*Income of the experiment stations from all sources for the fiscal years 1934 and 1935*

Source of funds	1934	1935
Federal:		
Hatch Act.....	\$750,000.00	\$765,000.00
Adams Act.....	731,000.00	743,000.00
Purnell Act.....	2,880,000.00	2,880,000.00
Appropriations for insular stations.....	69,973.00	68,936.00
Total Federal funds.....	4,430,973.00	4,456,936.00
Supplementary:		
State appropriations and allotments.....	6,704,469.23	6,722,776.43
Fees.....	460,025.10	560,345.53
Sales.....	1,310,207.49	1,532,339.30
Miscellaneous.....	542,717.65	710,840.80
Balance from previous year.....	740,062.72	1,089,023.78
Total supplementary funds.....	9,757,482.19	10,615,325.84
Grand total.....	14,188,455.19	15,072,261.84
Income 1935 over that of 1934.....		883,806.65

The income from other than Federal sources during the fiscal years 1934 and 1935 is shown by States in table 2.

TABLE 2.—*Income of the experiment stations from other than Federal sources for the fiscal years 1934 and 1935*

Station	1934	1935	Station	1934	1935
Alabama.....	\$190,637.35	\$176,508.83	Nevada.....	\$9,133.04	\$11,996.03
Alaska.....	5,426.29	9,198.43	New Hampshire.....	47,894.03	65,723.80
Arizona.....	77,107.14	86,878.75	New Jersey.....	446,725.15	463,018.16
Arkansas.....	66,417.51	75,161.90	New Mexico.....	53,122.74	56,249.34
California.....	881,237.37	877,093.22	New York (Cornell).....	667,513.05	580,305.72
Colorado.....	133,580.60	140,027.52	New York (State).....	380,114.64	357,532.91
Connecticut (State).....	205,191.13	216,214.07	North Carolina.....	100,133.55	124,912.85
Connecticut (Storrs).....	38,258.44	42,491.10	North Dakota.....	87,693.91	84,418.64
Delaware.....	35,340.33	35,938.20	Ohio.....	689,985.67	804,404.55
Florida.....	327,546.24	357,644.99	Oklahoma.....	162,776.83	139,430.39
Georgia.....	35,881.47	42,664.03	Oregon.....	185,019.49	205,934.92
Hawaii.....	21,694.78	24,066.95	Pennsylvania.....	153,152.49	167,130.92
Idaho.....	25,173.14	27,800.86	Puerto Rico.....		111,328.25
Illinois.....	366,669.40	425,044.04	Rhode Island.....	5,589.03	7,897.70
Indiana.....	626,903.35	734,003.48	South Carolina.....	113,194.61	132,589.09
Iowa.....	240,191.93	246,891.95	South Dakota.....	39,028.32	39,217.74
Kansas.....	172,149.91	170,357.65	Tennessee.....	32,934.11	36,545.74
Kentucky.....	243,035.74	252,075.44	Texas.....	489,957.54	531,425.81
Louisiana.....	79,204.32	108,618.96	Utah.....	66,240.41	66,656.61
Maine.....	50,741.12	49,594.01	Vermont.....	22,001.80	23,351.18
Maryland.....	98,041.96	84,899.63	Virginia.....	85,980.85	88,912.31
Massachusetts.....	219,902.01	232,394.72	Washington.....	77,254.49	195,857.69
Michigan.....	262,818.26	271,345.14	West Virginia.....	70,322.84	81,387.84
Minnesota.....	369,692.84	419,462.61	Wisconsin.....	439,749.00	410,296.09
Mississippi.....	103,288.53	166,081.47	Wyoming.....	75,041.29	120,043.53
Missouri.....	121,786.09	128,094.52			
Montana.....	98,615.01	139,617.74	Total.....	9,757,482.19	10,615,325.84
Nebraska.....	160,391.05	168,527.82			

The income of the stations from other than Federal sources, \$10,615,325.84, was 70.4 percent of the total, and \$857,843.65, or 8.79 percent more than for the preceding year. The greater income for

the year 1935 resulted from an increase of \$348,961.06 in the amount of balances carried over from the preceding year, \$18,307.20 in State appropriations and allotments, \$222,131.81 in sales receipts, \$100,-320.43 in fees, and \$168,123.15 in miscellaneous income. The decline in total State and other supplementary support, first realized in 1932 and continued for 4 consecutive years, appears to have reached the low point of the income curve in 1934 and to have reverted into an upward trend in 1935. A decrease in total station income of \$1,388,-177.79, recorded for the fiscal year 1934, was followed by an increase of \$883,806.65 for 1935. Most stations for the fiscal year 1935 reported an increase in State and other supplementary support, and comparatively few stations reported decreases, which in most instances were only nominal. The increases ranged from 0.48 percent to 153.5 percent, and the decreases from 0.46 percent to 14.34 percent.

For the support of the stations during the fiscal year 1935 the Federal Government contributed, in the aggregate, about \$1 for every \$2.38 received from State and other sources, as compared with \$1 for every \$2.20 in the preceding year, thus further reflecting the upward trend of supplementary income.

INCREASED INCOME UNDER THE BANKHEAD-JONES ACT

The outstanding event of the year affecting agricultural research was the passage of the Bankhead-Jones Act providing for research into basic laws and principles relating to agriculture and for the further development of cooperative agricultural extension work and the more complete endowment and support of land-grant colleges. The part of the act, approved June 29, 1935, which provides for research is as follows:

BANKHEAD-JONES ACT

AN ACT To provide for research into basic laws and principles relating to agriculture and to provide for the further development of cooperative agricultural extension work and the more complete endowment and support of land-grant colleges.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

TITLE I

SECTION 1. The Secretary of Agriculture is authorized and directed to conduct research into laws and principles underlying basic problems of agriculture in its broadest aspects; research relating to the improvement of the quality of, and the development of new and improved methods of production of, distribution of, and new and extended uses and markets for, agricultural commodities and byproducts and manufactures thereof; and research relating to the conservation, development, and use of land and water resources for agricultural purposes. Research authorized under this section shall be in addition to research provided for under existing law (but both activities shall be coordinated so far as practicable) and shall be conducted by such agencies of the Department of Agriculture as the Secretary may designate or establish.

SEC. 2. The Secretary is also authorized and directed to encourage research similar to that authorized under section 1 to be conducted by agricultural experiment stations established or which may hereafter be established in pursuance of the Act of March 2, 1887, providing for experiment stations, as amended and supplemented, by the allotment and payment as provided in section 5 to Puerto Rico and the States and Territories for the use of such experiment stations of sums appropriated therefor pursuant to this title.

SEC. 3. For the purposes of this title there is authorized to be appropriated, out of any money in the Treasury not otherwise appropriated, the sum of \$1,000,000 for the fiscal year beginning after the date of the enactment of this title, and for each of the four fiscal years thereafter \$1,000,000 more than the amount authorized for the preceding fiscal year, and \$5,000,000 for each fiscal year thereafter. Moneys appropriated in pursuance of this title shall also be available for the purchase and rental of land and the construction of buildings necessary for conducting research provided for in this title, for the equipment and maintenance of such buildings, and for printing and disseminating the results of research. Sums appropriated in pursuance of this title shall be in addition to, and not in substitution for, appropriations for research or other activities of the Department of Agriculture and sums appropriated or otherwise made available for agricultural experiment stations.

SEC. 4. Forty per centum of the sums appropriated for any fiscal year under section 3 shall be available for the purposes of section 1: *Provided*, That not to exceed 2 per centum of the sums appropriated may be used for the administration of section 5 of this title. The sums available for the purposes of section 1 shall be designated as the "Special research fund, Department of Agriculture", and no part of such special fund shall be used for the prosecution of research heretofore instituted or for the prosecution of any new research project except upon approval in writing by the Secretary. One-half of such special research fund shall be used by the Secretary for the establishment and maintenance of research laboratories and facilities in the major agricultural regions at places selected by him and for the prosecution, in accordance with section 1, of research at such laboratories.

SEC. 5. (a) Sixty per centum of the sums appropriated for any fiscal year under section 3 shall be available for the purposes of section 2. The Secretary shall allot, for each fiscal year for which an appropriation is made, to Puerto Rico and each State and Territory an amount which bears the same ratio to the total amount to be allotted as the rural population of Puerto Rico or the State or Territory bears to the rural population of Puerto Rico and all the States and Territories as determined by the last preceding decennial census. No allotment and no payment under any allotment shall be made for any fiscal year in excess of the amount which Puerto Rico or the State or Territory makes available for such fiscal year out of its own funds for research and for the establishment and maintenance of necessary facilities for the prosecution of such research. If Puerto Rico or any State or Territory fails to make available for such purposes for any fiscal year a sum equal to the total amount to which it may be entitled for such year, the remainder of such amount shall be withheld by the Secretary. The total amount so withheld may be allotted by the Secretary of Agriculture to Puerto Rico and the States and Territories which make available for such year an amount equal to that part of the total amount withheld which may be allotted to them by the Secretary of Agriculture, but no such additional allotment to Puerto Rico or any State or Territory shall exceed the original allotment to Puerto Rico or such State or Territory for that year by more than 20 per centum thereof.

(b) The sums authorized to be allotted to Puerto Rico and the States and Territories shall be paid annually in quarterly payments on July 1, October 1, January 1, and April 1. Such sums shall be paid by the Secretary of the Treasury upon warrant of the Secretary of Agriculture in the same manner and subject to the same administrative procedure set forth in the Act of March 2, 1887, as amended June 7, 1888.

SEC. 6. As used in this title the term "Territory" means Alaska and Hawaii.

SEC. 7. The Secretary of Agriculture is authorized and directed to prescribe such rules and regulations as may be necessary to carry out this Act.

SEC. 8. The right to alter, amend, or repeal this Act is hereby expressly reserved.

The Bankhead-Jones Act authorizes substantial increase in Federal aid for agricultural research during 1936 and succeeding years. For the fiscal year ending June 30, 1936, the authorization for research is \$1,000,000. Further increases are authorized for subsequent years, reaching a final total of \$5,000,000 for the fiscal year 1940.

The Office of Experiment Stations has been designated to represent the Department in all matters relating to the administrative

details in the expenditure of the research funds allotted to the States and to aid in the promotion of research activities under this act and of coordination with other agricultural research in the same general way as it has heretofore in relation to the Hatch, Adams, and Purnell Acts. Regulations and policies for the administration of this important legislation were being formulated at the close of the year, and substantial progress had been made in setting up a satisfactory program of research.

PERMANENT IMPROVEMENTS

Additions to permanent improvements at the stations during the year were largely of a minor nature and designed mainly to maintain the equipment and to provide facilities called for by the various research activities in progress. Such facilities were fairly well maintained despite limited funds for the purpose.

Many of the stations continued to take advantage of the cooperation offered by the Public Works Administration, Civil Works Administration, and other emergency and relief agencies to repair and recondition equipment and to improve experiment fields. In one or two instances the institution, of which the experiment station forms a part, entered upon an extended building program financed from P. W. A. funds which resulted in improvements and expansion of equipment facilitating and broadening, either directly or indirectly, the work of the station. Donations of funds, lands, and buildings were also received by several stations from organizations representing different industries or activities for the promotion of research on problems in which they are directly interested.

For the year ended June 30, 1935, the stations reported an expenditure of \$1,062,357 for buildings and equipment, including library purchases to the amount of \$46,486, and additions to and replacements of scientific apparatus, farm implements and machinery, and livestock, amounting to \$169,245, \$175,239, and \$98,508, respectively. This was nearly one-third less than in 1934, and was the smallest recorded since 1921.

The more important improvements are here briefly noted.

The Alabama Station, at a cost of about \$6,900, constructed a dam and water-storage ponds; a storage house for chemicals, garden implements, scales, and small tools of the departments of botany, forestry, and horticulture; and constant-temperature and moisture chambers for use in the study of the dynamic properties of soils.

To replace a barn destroyed by fire, the Arkansas Station erected a new building on the station farm for housing livestock and machinery. A crew of F. E. R. A. workers was employed the year round on the station and branch station farms, working on roads, drainage and soil-erosion projects, and on experimental plats, producing benefits estimated at \$10,000.

At a cost of about \$3,970 the California Station provided animal sheds at Fontana, supplied veterinary science buildings and improvements at Strawberry Canyon, and improved cold-storage facilities at Berkeley.

The Florida Station received a 40-acre tract of land and \$650 in cash from the Florida Agricultural Research Institute for the devel-

opment of citrus work. This station, at a cost of approximately \$5,550, constructed at Gainesville a cattle-feeding barn, a veterinary isolation building, a horticultural laboratory, an animal house and laboratory, an agronomy storage building, and a spectroscopic laboratory. At the North Florida Branch Station, at a cost of about \$3,600, a grain storage and implement barn and a cattle-feeding barn were supplied.

With the aid of F. E. R. A. labor the Georgia Station erected a fertilizer and seed barn of hollow tile and other fireproof material for \$4,000, improved a dam and cleaned out a lake for \$2,000, and constructed at the Mountain Branch Station an agricultural exhibit pavilion for \$1,000.

The University of Hawaii erected a two-story agricultural building, 60 by 120 feet in size, and costing \$68,000, to furnish room for the offices of the experiment station and laboratories for agronomy, chemistry, plant pathology, and soils.

For the use of the Idaho Station a farm of 130 acres, adjacent to the university farm at Moscow, was acquired for \$14,000, including the remodeling of the existing buildings. A tract of 15 acres, near Parma, was purchased at a cost of \$1,625 for the outlying work of the station in that part of the State.

The Iowa Station built a corn-research laboratory for about \$2,000 and secured a lease for 12 years of a farm of 148 acres purchased by the alumni association of the college.

At the Maryland Station the renovation and remodeling of the dairy building, including the veneering of the structure with brick, replacing the flat with a raised roof, and providing other renewals and improvements, was undertaken at a cost of \$30,000.

The Massachusetts Station expended about \$7,500 on the reconditioning and remodeling of a building to serve as a nutrition laboratory, including the provision of space for work with small animals. The improvement of the building and its adaptation to the purposes in view will be continued as funds become available. As the result of much interest on the part of nurserymen the State legislature provided a special fund for the enlargement of laboratory and greenhouse facilities at the Waltham Field Station and for the employment there of two additional research workers on nursery problems.

In Minnesota funds were made available from university reserves for an office building and laboratory at the SE Substation at Waseca, to supply facilities for studies on the embryological development of young animals, for handling the data growing out of the inbreeding investigations with swine, and for enhancing the breeding work with corn, sweetclover, and sugar beets. At the Cloquet Substation an office and laboratory building, costing about \$5,000, was provided for work in connection with field studies; and a seed-extraction plant, costing about \$1,000, was constructed for a detailed study of forest-tree seeds.

At the Maine Station a cellar for overwintering bees was built for \$1,240, and a laboratory for studies in game management for \$1,869.

With the use of F. E. R. A. labor the Montana Station fenced lots and corrals at Bozeman, and constructed a cattle-feeding shed at the Northern Montana Branch Station, at Havre.

The Nevada Station began the reconstruction of the station dairy building at Fallon, destroyed by fire November 10, 1934. The dairy barn, 150 feet long, and the granary and hay barn were rebuilt with all floors and mangers of concrete and the roofs of corrugated galvanized iron. Many of the fences on the station farm at Reno were reconstructed with the use of relief workers.

A small dairy laboratory, at a cost of \$500, and a poultry bronchitis vaccine laboratory, at a cost of about \$1,800, were built at the New Hampshire Station.

The New Jersey Station reported the building of a new greenhouse, costing \$3,072, for the use of the plant physiology department in its studies to determine the role of minor elements in plant nutrition. The clearing and draining of 40 acres of land, and the clearing of woodlands on the horticultural farm, were continued with relief forces, and the roads around the buildings also were improved.

The New York State Station provided a fruit-juice laboratory, costing \$3,500, and a sprinkler irrigation system, for \$1,000, and devoted about \$1,000 to the remodeling of the chemical laboratory.

A private concern, interested in the subject, supplied the North Carolina Station, at a cost of \$1,000, with a poultry house for the study of the effect on poultry of feeding fermented mash.

The North Dakota Station made use of F. E. R. A. labor in the construction of a granary and machine shed, costing \$872, and a turkey brooder house, costing 400.

A general-purpose barn was erected at the Oklahoma Station at a cost of about \$2,000.

An experimental mushroom house was donated to the Pennsylvania Station by the Mushroom Growers Cooperative Association of Pennsylvania.

The Rhode Island College, with the use of P. W. A. funds, provided, among other structures, a home economics building, costing \$230,000, a dairy barn, wagon shed, and garage, with the necessary land, at an outlay of \$77,000, and a sprinkler irrigation system for \$22,000, which will aid and expand the work of the station.

The South Carolina Station began the construction of a modern and practically fireproof dairy barn, estimated cost \$35,000, to replace the barn burned in March 1935, and at a cost of \$3,500 rebuilt a brooder house damaged by fire. In addition, the head house of the botany greenhouse was enlarged at a cost of \$3,500 to furnish more office and laboratory space. A stationary spray plant, costing \$2,000 was installed in the experimental orchards. Two large cold-storage rooms for fruits and vegetables and physiological studies were provided at a cost of \$2,500, and a water system, costing \$600, was put in at the Coast Substation. The cost of these improvements totaled approximately \$47,000.

At a cost of about \$1,900 the Texas Station provided hog pens and chicken houses with fences, at College Station, and also constructed fences at the Beeville Substation.

The Washington State Game Commission supplied the Washington Station with a brooder house costing \$2,000 for experimental work with game birds, and the State purchased for \$13,600 a tract of 160 acres of land adjoining the college farm for a soil-erosion-

control nursery and other experimental work. A building program of the college, financed from P. W. A. and State emergency relief funds, included the construction of a power plant for \$285,000, a chemical building for \$255,000, and a science building for \$292,000, which will furnish advantages indirectly of value to the experiment station. Additional amounts of \$40,000 and \$32,000 were allowed for equipment of the chemistry and science buildings, respectively.

The Wyoming Station built a new type straw-packed poultry house for \$700, extended the station poisonous-plant garden at a cost of \$500, provided an exhibit hall and museum at the Campbell County farm for \$3,800, and made the final payment of \$3,650 on land purchased for experimental purposes at the Lincoln County Experiment Station.

RESEARCH PROJECTS AND PROGRAMS

The 7,000 station projects reported as active during the year provided for research in almost every phase of farming and rural living, including land use and conservation; crop adjustment; economical production, distribution, marketing, and use of plant and animal products, and improvements of the quality of such products; protection against animal and plant diseases, insects, and other pests; tenancy, taxation, and other matters affecting the efficiency of farm business management; and the betterment of the rural home and rural life. There was evidence of increasing emphasis on efficient and remunerative production and on the economic and social aspects of rural life.

The research work of the stations has come to be differentiated into two more or less distinct types, (1) more formal and continuous fundamental research and (2) less formalized and perhaps temporary activities relating to recovery and readjustment and emergency conditions.

The projects supported by Adams and Purnell funds at the stations dealt with phases of practically all of the above subjects. The number of such projects increased from 460 and 1,578 in 1933-34 to 497 and 1,697, respectively, in 1934-35. The increase is probably an indication of the attempts made by the experiment stations to adapt their research programs to the study of emergency and adjustment problems. The increased number obviously reduces the support to individual studies and, from that standpoint, is undesirable. However, the emergency activities required immediate attention and, in many cases, provided for additional funds and cooperative study of which it was necessary to take advantage without undue delay.

The number of new projects supported by the Adams and Purnell funds was relatively large as compared with previous years, although less than in 1933-34, when there were 56 Adams and 264 Purnell projects, respectively.

The Adams and Purnell projects were distributed by major objectives and allotment of funds as shown in table 3.

TABLE 3.—*Distribution of Adams and Purnell projects by major objectives*

Item	Projects		Amount expended 1934-35	
	Adams	Purnell	Adams	Purnell
Improvement, more economical production, and better utilization of plants and plant products:				
Improving quality, disease resistance, and hardiness by breeding.....	<i>Number</i> 53	<i>Number</i> 94	<i>Dollars</i> 87, 111	<i>Dollars</i> 175, 407
Protection against insects, plant diseases, and rodents.....	152	235	164, 566	288, 117
Conservation, maintenance, and management of the soils and crops.....	91	273	142, 954	468, 053
Improved methods of producing, handling, storing, utilizing, and marketing plant products.....	22	140	33, 154	231, 205
Physiology of growth and fruiting.....	41	53	77, 747	91, 000
Improvement, more economical production, and utilization of farm animals and animal products:				
Development of improved animals by breeding.....	15	36	21, 918	47, 182
Feeding and management for more economical production.....	48	212	98, 892	447, 690
Protection against diseases, parasites, and poison plants.....	52	82	81, 676	128, 572
Efficient production, processing, handling, and marketing practices.....	12	124	12, 960	192, 504
Physiology of growth, reproduction, and milk flow.....	9	20	14, 690	24, 370
The betterment of the family, the home, and the community:				
Physical improvement of the family through new knowledge of food composition, improvement in food preparation, analyses of dietary practices, development of new standards, and fundamental discoveries concerning factors affecting growth, nutrition, and health.....	2	114	1, 868	157, 876
Betterment of the home through information on household equipment and its arrangement and efficient use, factors affecting the selection and care of clothing and textile fabrics, methods and standards of household buying, consumption habits and standards, possibilities of contributions of homemakers to family income, and factors determining standards of living in various sections of the country.....		54		74, 859
Social organization and improvement.....		42		72, 859
Population movement and changes.....		1		1, 400
Farm business improvement:				
Taxation.....		37		77, 744
Land utilization.....		76		148, 418
Financial relationships—tenancy, mortgages, investments, adjustments.....		29		41, 639
Business organization and cost.....		52		102, 958
Marketing organizations.....		23		29, 885
Total.....	497	1, 697	737, 536	2, 801, 738

COORDINATION AND COOPERATION

There was notable progress during the year in organization and extension of coordinated and cooperative research—national, regional, and local. The stations were especially active in cooperation with the Department, other stations, State agencies, and local organizations in efforts to plan and coordinate research and to use the resulting information in support of the national and State adjustment and relief policies. A large proportion of the 7,000 projects in agriculture and home economics now under investigation at the stations deal with the more urgent rural problems, especially those concerned with recovery and adjustment measures.

The Office of Experiment Stations examined and recorded during the year 798 new or revised cooperative agreements between bureaus of the Department and the experiment stations, representing 734

major research undertakings. All of the 50 State stations and all but 1 of the research bureaus of the Department had formal cooperative agreements of some kind, besides a large number of informal cooperative activities. Numerous cooperative undertakings organized on an emergency basis as parts of the national recovery program were again participated in by practically all the stations and Department bureaus.

Again, practically the entire research programs of some of the Department bureaus were conducted in cooperation with State stations. The total number of cooperative agreements is 5 percent more than during the previous year. This relatively small increase cannot be attributed to returning State income to the stations, even though such income was approximately 9 percent greater than during the previous year. The major increase in income from within the States has taken place subsequent to the increase in coordinated cooperative research activities.

The number of cooperative studies per station ranged from 1 to 43. Subjects under cooperative study again covered the entire field of agricultural and rural-life problems. Increasing emphasis was placed on soil conservation and use, and especially on adjustments in farming by regions and type-of-farming areas from the standpoint of agricultural adjustment in general.

The cooperative studies were distributed by subjects as follows: Improvement of quality and lowering cost of production of cereal, forage, textile, and other field crops and fruit and truck crops, improvement of pastures and ranges, and combating crop-plant diseases, 306 as compared with 306 the previous year; agricultural economics, developing sounder and more businesslike farm management and bettering rural living conditions, 141 as compared with 107; improvement of animal products, especially meats, combating animal diseases, and improving the breeding of animals for more desirable and profitable characters, 71 as compared with 76; soil surveys, improvement of soil fertility and productiveness, and fertilizer development and improvement, 67 as compared with 67; combating insect pests of plants, animals, and human beings, 76 as compared with 67; introducing greater efficiency and economy into agricultural production operations by developing and adapting engineering principles, soil-moisture control, and the use of water in irrigation farming, 58 as compared with 59; improvement of dairy stock and products and introducing economy into dairy commodity production, 32 as compared with 35; improvement of timber crops, combating forest-tree insects and diseases, and forest maintenance, management, and reseedling, 24 as compared with 28; improvement of human foods and of food-management practices, 5 as compared with 8; maintenance of economically important wildlife and combating animal pests, 6 as compared with 5; studies of weather conditions important to farming and the marketing of farm products, 2 as compared with 2; and studies of the conservation and development of land and water resources for agricultural purposes, 10 as compared with none the previous year.

With reference to problems of commodity production, it is significant that 59 cooperative research undertakings related to problems of animal production, 34 to cotton, 32 to cereal crops not including corn, 27 to tobacco, 25 to forage crops, 21 to potatoes, and 14 to corn.

In addition, 118 cooperative research undertakings related to the control of economically important insect pests and plant diseases, 72 to various specific phases of land development and use, 31 to the development of, use, and application of fertilizers for crops, and 22 to the development and use of machinery for crop production.

The following specific examples are significant of important developments in cooperative and coordinated research: Reliable information was needed on a Nation-wide basis which could be used as a guide for rational adjustments in farming by regions and types-of-farming areas. The A. A. A. through the Bureau of Agricultural Economics was provided with funds to undertake the synthesis of all such pertinent agricultural information available in the States. To accomplish the objectives sought within the time limits imposed, coordinated effort involving the trained workers and wide experience of the Department and each of the State stations was imperative. With the existence of mutual sympathetic understanding resulting from previous similar experiences it was relatively simple to make arrangements whereby each of the 48 State stations entered immediately into cooperation with the Bureau of Agricultural Economics, furnishing the best leadership and technical assistance available, and the study was carried out. In addition to the information of national scope and significance the individual State stations collected and synthesized supplemental facts and information as a foundation for further study and planning consistent with State and local conditions and problems.

The second year of a coordinated study of rural relief and its organization carried out under the auspices of the Federal Emergency Relief Administration also was completed. During the year about 30 of the State stations participated in this study in cooperation with the Office of Experiment Stations and the Bureau of Agricultural Economics.

In September 1934 the State agricultural colleges, experiment stations, and extension services in the Tennessee Valley area entered into a written cooperative agreement with the Tennessee Valley Authority. Under the agreement the seven State stations concerned undertook a cooperative study of fertilizers, fertilizer ingredients, and fertilizer practices adapted to the needs of the valley, with due consideration for available natural resources as regards raw phosphates, water power, and natural fuel. By the end of the year similar cooperative investigations involving the same stations and the Tennessee Valley Authority were also under way on the control of soil erosion and run-off water losses and soil mapping and agricultural planning in relation to land use and land management adjustments. By conducting the research work on definite soil types and having maps showing the reaction of these types, it will be possible to give the data their proper interpretation and extension.

Additional outstanding examples might be given in the soil erosion, cotton, pasture improvement, soil resources survey, and other regional and national programs which were continued from the previous year and expanded and strengthened.

The passage of the Bankhead-Jones Act (p. 3), during the closing days of the year, which provides among other things for additional agricultural research by both the Department and the State stations, gave added impetus to more thorough coordination of re-

search between stations regionally and between stations in regions and the Department in lines of work specified in the act.

No discussion of coordination and cooperation as it affects agricultural research would be complete or adequate that did not take account of the growth of unforced, more or less spontaneous, interdepartment, interbureau coordination of effort within the Department of Agriculture and the individual experiment stations. This has been an outstanding development during recent years, recognizing community of interest and the advantage of concerted effort in many specific as well as general lines of work.

AGRICULTURAL RESEARCH AND SERVICE

Research in the interest of agriculture and rural life is the main business of the United States Department of Agriculture and the agricultural experiment stations. Their service in this respect is large and varied.

Every day the United States Department of Agriculture does for you a multitude of necessary things that you could not possibly do for yourself. It guards your food supply from adulteration and dangers to health and improves its quality through plant science and animal husbandry. It keeps watch on production at home and abroad, so that supply may be adjusted to demand and prices kept in line with values. It standardizes and grades commodities, seeks uses for waste products, protects the forests and wildlife, defends the country against foreign insects and animal and plant diseases, maps the Nation's soils, studies how our land resources may be better utilized, forecasts floods, storms, and frosts, and supervises road construction. The progress of science and civilization makes these services indispensable, while at the same time removing them from the sphere of individual action.²

Much the same may be said of the experiment stations which in every State, Territory, and community are supplementing and extending the work of the Department, making the combined service more effective locally, regionally, and for the Nation as a whole.

Research essential to the formulation of reliable regulatory measures and methods and sound plans of agricultural recovery, adjustment, and farm practice serves the consumer as well as the producer, the city home as well as the country home. Its ultimate aim is better living in general. Efficient production and distribution of farm products of good quality at a reasonable price is of as much concern to city dwellers as to farm people, to industry as to agriculture. It should never be forgotten also that the farmer is a consumer as well as a producer. The immediate concern of agricultural research is, of course, to make the farmer a more efficient producer, but also, among other things, to enable him to become a more liberal purchaser and a better user of the commodities of industry.

The director of the Illinois Station comments on what science has done for agriculture in that State as follows:³

Good farming does not happen, but is the product of careful, painstaking, and often long-continued research and experimentation. There could be no good farming without superior varieties of crops and types of livestock, without reliable and safe growing methods, or without sound marketing practices. As the principal source of all these good farming aids, research and experimentation therefore stand as the very basis of a permanent and profitable agriculture. * * * What research and experimental work has done in soils and crops for the advancement of good farming has been duplicated in all

² Chew, A. P. SCIENCE SERVING AGRICULTURE. U. S. Dept. Agr. p. 1. 1933.

³ Ill. Agr. Expt. Sta. Rept. 1933-34; 5-6. 1935.

other lines of agriculture. The history of superior livestock, higher-quality fruits and vegetables, improved dairy products, reduced costs of production, advanced marketing methods, control of insects and diseases, and all other good farming practices is largely the history of research and experimental work. * * * With changing conditions, [however], farming will be good farming only so far as it changes its methods to conform to these changing conditions. Methods cannot be changed intelligently unless research and experimentation point the way.

The State experiment stations, scattered throughout the country, cooperating with the Department and in close contact with local conditions and problems and familiar with the local background, are in a particularly strong position to build their research effectively on the basis of past experience, present needs, and varied environment and habits of thought without revolutionary disruption and ill-considered innovations and on a sound scientific basis. The following statement from a report of the director of the California Station is typical of the judgment of State station directors:⁴

Even more so than in the past, progress and success in farming today depend directly upon the facts discovered by science and the application of those facts to the problems faced by the farmer. As the problems of agriculture have grown in number and complexity, particularly with changing economic conditions, so necessarily has the scope of the investigational work of agricultural experiment stations increased and widened.

One fact is inescapable. Irrespective of the economic conditions and type of government under which farming enterprises are maintained, the discovery and use of new facts constitute the best means for aiding the farmer and his family to improve the circumstances under which they work and live. Experimentation and research cannot promise panaceas or quick cures for all of the ills and problems of agriculture, but the discovery of truths does provide methods and point the way by which the problems of the farmer can be attacked.

Speaking of improved conditions and outlook in Connecticut, and the application of scientific research to practical problems, the director of the station in that State says: "Whatever the cause, the effect has been to clear the skies and give us a renewed faith in the task of 'putting science at work for agriculture.'"

SOME RESULTS OF RECENT STATION WORK

The following review, prepared by specialists of the Office of Experiment Stations from current publications of the stations, communications from station directors, and other authoritative sources, attempts simply to present a few examples of station work in terms of major objectives of special significance at the present time. The review is necessarily selective. It is not a complete summary of all recent accomplishments of the stations as a whole or individually. Many other equally significant examples of station work might be included. It is hoped, however, that the review will serve to indicate especially that the work of the stations is of value to urban as well as rural people and in line with national as well as local recovery and adjustment policies.

PLANT PRODUCTION AND PRODUCTS

Research relating to plant production and products naturally and appropriately demands and receives a large share of the attention of

⁴ Calif. Agr. Expt. Sta. Bien. Rept. 1932-34: i-iii.

the experiment stations. The program of research in this field is large and varied. A few of the great number of examples of research relating to land use and soil conservation and efficient production and disposal of crops recently reported follow:

LAND USE AND SOIL CONSERVATION

Secretary Wallace, in a recent comment on the interdependence between agriculture and the rest of the national economy, pertinently calls attention to the importance of conserving and utilizing efficiently "the Nation's basic natural resource, the soil." He says, "when the soil suffers beyond a certain point, the people of the United States are running up a bill which few civilizations have ever been able to pay." Continuous cropping without adequate return of fertility removed in crops and neglect of the ravages of soil erosion are major factors in running up such a bill.

Along with increase in what might be termed "service work on soils", there have been great advances in soil science as evidenced by the research output of the Department, the experiment stations, and like agencies all over the world. This was strikingly brought out in the proceedings of the recent Soil Science Conference in Oxford, England, July 31 to August 7, 1935, in which many American scientists took a leading part. The papers and discussions of this congress dealt with a wide range of problems in soil physics, chemistry, and microbiology, soil fertility, soil structure, classification, and methods, and soil conservation and improvement besides numerous more specific questions. It was shown especially that soil mapping has reached such a stage of refinement that the maps now produced are of great value in all land-classification and land-utilization work, as well as in planning soil-erosion control and field experiments and in making recommendations to farmers.

Some specific examples of recent work of experiment stations relating to soil conservation and land use are as follows:

Quantitative comparison of land types.—The Michigan Station has developed a method of graphic and quantitative comparison of land types which is proving useful in more exact determination of the needs of the soils and their crop adaptations.

Utilization of cut-over lands.—The Minnesota Station has recently been engaged in an intensive study of land utilization in the cut-over area of the State, which has culminated in the publication of a program of land use in northern Minnesota. The results of the study include a broad general classification of 14 counties into agricultural and conservation zones. The problems and methods of zoning were developed. Consideration was given to improved utilization of both forest and agricultural lands. Advantages and costs of settler relocation were studied. Estimates were made of economies in local government possible through governmental changes and concentration of scattered settlements. The publication of the results of this study, which was made in cooperation with the Department of Agriculture, has met with a very favorable reception, one comment being that—

It takes one of the most difficult of marginal or barely submarginal farm areas in this country, analyzes it carefully both agronomically and economically, and tries to reach a practicable decision on what to do about it.

Land use in Pennsylvania.—The Pennsylvania Station has completed a survey of the land resources of the State, with a view to suggesting the most desirable future use of different land areas. A large-scale map of the State has been prepared showing the areas which probably could be used to best advantage for agriculture, for forestry, or for recreation, respectively. The agricultural lands which are clearly submarginal under present conditions and which should revert to forestry or recreational use are indicated. This information has been requested by the State Planning Board; it is considered basic to the most effective prosecution of the rehabilitation program in rural districts and to the public-works program of the Federal Government.

Land classification and use in Washington.—The Washington Station reports considerable progress during the year in the study of land classification and use, supported partly by W. E. R. A. funds. A large amount of information has been collected regarding type of land; land ownership; assessed value of improved, unimproved, and timber land; tax delinquency; school and road data; distribution of rural population; productivity of land; precipitation; temperature; and types of soil with a view to classifying the land according to its best use, that is to say, whether it should be used for crops, grazing, forestry, watersheds, recreation, site purposes, residential, or other purposes. A large number of maps were completed picturing in detail the information covered by the above-named subjects. This study is considered of fundamental importance with regard to a better understanding of the land resources of the State and intelligent planning concerning future uses thereof. The information developed should make possible the valuation of land according to its earning power, and disclose areas which may be developed for farming.

Use and resettlement of marginal lands.—From a study of the intensity of land use and resettlement problems in Missouri, the Missouri Station reaches the conclusion that it is doubtful whether people on marginal agricultural lands should be resettled in areas of better agricultural lands in that State. The station is of the opinion that many of the poorer lands of Missouri are more worthy of intensive development than the better agricultural lands from the standpoint of general improvement of future living standards.

Nitrogen conservation in humid soils.—Among means suggested by the Ohio Station for arresting rapid depletion of nitrogen in soils under present methods of farming are growing of legumes, to promote beneficial bacterial action, particularly fixation of nitrogen and checking of erosion by growth of more hay and pasture crops, preferably legumes—in other words a more rational system of land use.

Soil conservation in dry regions.—Recommendations for conserving soil moisture and maintaining a more diversified and stable type of agriculture in regions of 15 to 25 inches of rainfall, made by the Kansas Station in cooperation with the Department of Agriculture, are increase of organic matter in the soils, and maintenance of grass or other plant cover, especially use of perennial grasses and legumes to prevent wind erosion.

Strip cropping to prevent soil erosion.—The successful use of erosion-resistant crops planted in strips on the soil contour to prevent ero-

sion is reported by the Oklahoma Station. Attention is called particularly to the efficiency of alfalfa planted on the contours in reducing the run-off and loss of soil from cotton fields even with a rainfall of 1.56 inches in a single day. The station has also studied the relative effectiveness of other crops and forms of vegetation in reducing run-off and soil erosion. It has found a combination of terracing or contouring and strip cropping to be a practicable and effective method of reducing the enormous losses due to run-off and erosion.

Progress of land terracing in Texas.—Texas is reported to have 6,895,548 acres of land either protected from erosion or in the process of protection, including areas which may have been reterraced. In 1933, 15,465 individual farms covering 604,386 acres in 173 counties were terraced. The introduction and extension of such protective measures in the State are largely the result of investigations relating to soil erosion carried on by the Texas Station for many years.

SOIL FERTILITY AND FERTILIZERS—GENERAL

A large part of the recent work of the stations relating to soil fertility and fertilizers is noted in this report under the crops or products to which it specifically pertains, as, for example, on pages 24, 31, 35, 38, 42, 43, 47, 48, 50, 52, 53, 54, and 61. There are noted below certain investigations which have a broader application than any one specific crop or product.

Rapid soil tests.—Rapid chemical and pot tests worked out by various experiment stations furnish simple and inexpensive means of determining soil reaction and fertilizer needs and deficiencies, giving results which appear to be for some purposes as dependable as time-consuming and expensive field experiments and pot tests. Many stations have devised such tests, and the number is constantly being added to. The Florida, Indiana, and other stations have recently proposed tests which appear to have decided advantages for the purpose indicated.

Studying plant sap as an indicator of phosphorus needs of plants, the Florida Station found that crops that responded unfavorably, if at all, to phosphorus fertilizers were those of which the saps were relatively high in phosphorus in the absence of soil treatment with a phosphate carrier. Those that responded favorably, on the other hand, contained sap relatively low in phosphorus.

After a thorough study and trial of the Neubauer method (growing rye seedlings in small pots with various fertilizer treatments), the Indiana Station concludes that it is accurate and dependable as a means of determining fertilizer requirements of soils. It is relatively rapid and inexpensive.

Rarer elements of the soil.—In view of the fact that the effect of minute quantities of certain elements on growth of plants is attracting widespread interest, the New York (Cornell) Station has reviewed the literature of investigations on the subject and made analyses of samples of fertilizers obtained from manufacturers and distributors and representing the major types of fertilizers used in agricultural practices, which showed a wide variation in the number and quantity of rarer elements contained in these materials. Arsenic, barium, boron, and vanadium were present in determinable amounts, while traces of lithium, tin, and zinc were

detected in a few samples. The station studied the effect of the addition of copper, manganese, boron, and zinc, in quantities equal to the highest found in fertilizers examined to a synthetic fertilizer containing pure salts of nitrogen, phosphorus, and potassium, on the growth of oats on two types of soil, a productive silt loam and a coarse sandy loam. Slight increase in yield was observed in all cases. When the rarer elements were added in considerably larger amounts there was further slight increase in yield. Further experiments with these and other rarer elements on oats, timothy, and algae indicated as a rule a stimulating effect of the elements.

Continuing its investigations on selenium and other relatively rare toxic elements in soils and plants, the Wyoming Station has added especially to its information regarding the distribution of selenium-bearing shales and their relation to absorption of selenium by plants growing on them and tolerance of selenium by livestock (p. 97).

That many crop plants may suffer from a deficiency of magnesium in the soil was demonstrated in experiments reported by the Massachusetts Station among others. They differ to a marked degree in this respect. Buckwheat and spinach appear to be most affected; turnips, mangels, corn, and tobacco considerably so; small grains, grasses, clovers, and potatoes were only slightly affected. Plants sensitive to magnesium deficiency developed characteristic symptoms which serve as indicators of the deficiency. The content of magnesium in the plants was affected by the amount of precipitation during the season, being less in seasons of heavy rainfall. Addition of magnesium sulphate to the soil increased the amount of magnesium in the plants.

Under certain conditions, particularly on very acid soils, the New Jersey Station finds that the use of some form of magnesium in fertilizers may be advisable. If, however, the acid conditions are corrected the need for magnesium is largely eliminated.

Effect of long-continued irrigation.—In a study by the New Mexico Station of soils that had been cropped under irrigation for 40 years and similar types of virgin soil, it was found that the leaching out of lime is negligible owing to the enormous supply of lime in the soils; also that the irrigation water and sediments have supplied sufficient potash to offset that removed by the 40 years of cropping. Although the soils are naturally low in nitrogen there has been no important change as a result of the 40 years of cropping and irrigation. Some nitrogen had been supplied by growing alfalfa, but it is evident that nitrogen depletion is not so greatly to be feared as in moist climates.

Acidity of soils and fertilizers.—Fertilizers sometimes have a decided effect on acidity or basicity of soils and thus affect their productivity. A laboratory method for determining the residual effect on basicity or acidity of soils from applications of mixed fertilizers developed by the West Virginia Station has resulted in a more general recognition of the importance of fertilizer effects on soil acidity and a rapid development in the production of nonacid-forming fertilizers through the use of dolomitic limestone fillers. Since magnesium is deficient in many soils of the eastern United States, the dolomitic filler performs the dual function of correcting this deficiency and neutralizing the potential acidity of the fertilizer.

Studies of the liberation of soluble magnesium from limestones of different degrees of fineness show that a large part of the material should pass a 60-mesh sieve and all of it a 20-mesh sieve in order to meet the magnesium requirements during the first year.

Value of manure on the farm.—The Indiana Station finds the value of manure on the farm to be increasing as the native fertility of the land is diminished through cropping and the destructive forces of leaching and erosion, but advises that on most farms it will pay to supplement the manure with some sort of commercial fertilizer, especially phosphate. Manure contains only half as much phosphoric acid as nitrogen and potash. On light sandy soils, manure applied on wheat in winter gave much better returns than when applied for corn. On light-colored heavy soils, giving wheat a light winter dressing and applying the balance for corn was the most effective distribution. On variable soils, the most efficient use of manure was to first cover the light-colored areas, which were most in need of organic matter and nitrogen.

Availability of the phosphoric acid of rock phosphate.—Studies reported by the Texas Station showed that soft phosphate with colloidal clay and finely ground rock phosphate both contained phosphoric acid of much lower availability to plants than that of superphosphate, especially on neutral or basic soils such as generally prevail in Texas. The soft phosphate with colloidal clay is a finely divided phosphate of natural occurrence, which is a byproduct from mining rock phosphate in Florida. The finely ground rock phosphate was from Tennessee rock. The availability of the phosphoric acid in soft phosphate with colloidal clay was found to vary from 0 to 120, with an average of 40, compared with the phosphoric acid of superphosphate as 100. The availability was low on the slightly basic soils, high on one acid soil, but about the average on some of the other acid soils. The availability of the phosphoric acid of finely ground rock phosphate was only 40 percent of that of superphosphate. Its availability seemed to be lower on neutral or basic soils than on acid soils. On some acid soils, the availability of the phosphoric acid of both soft phosphate with colloidal clay and finely ground rock phosphate was equal to that of superphosphate, but on other acid soils the availability was decidedly less than that of superphosphate.

Fertilizing value of dicalcium phosphate.—After many trials a high-grade dicalcium phosphate, fluorine-free and well adapted to animal feeding, has been obtained by the Tennessee Station. The product can be made very cheaply and requires so little equipment that it can be produced on the farm or as a community undertaking.

Liming to reduce need for phosphate.—The Ohio Station has found that liming certain soils to a reaction approaching the maximum that can be obtained with ground limestone (about pH 7.8) greatly diminishes the need for adding phosphate fertilizers, apparently through increasing the availability of native soil phosphates. Whereas most crops showed large response to phosphates on the soils at pH 7, little or no response was shown at pH 7.5.

Toxic effect of fluorine in fertilizers.—Natural phosphates usually contain a considerable percentage of fluorine which passes into

superphosphates made from such phosphates. The Michigan Station has found that superphosphates containing 20 to 44 percent of phosphoric acid contain sufficient soluble fluorine to injure seriously the germination of corn. Partial removal of the fluorine by roasting the fertilizer resulted in less interference with germination. The amount of soluble fluorine was reduced by the addition of Brookston loam or Miami silt loam, resulting in a marked decrease in toxicity. Germination was seriously reduced when corn was planted in contact with the fertilizer and slight separation of fertilizer and seed greatly improved germination (p. 61).

To find whether fluorine in raw rock phosphates and superphosphates used as fertilizers is taken up in harmful amounts by crops grown on the soil, the Wisconsin Station determined the fluorine content of a number of forage crops grown on soils treated over long periods with such fertilizers, and concluded that not enough fluorine was absorbed by the plants to be harmful. Apparently most of the fluorine had been drained away in the ground water, but the drainage water contained enough fluorine to produce mottled teeth (p. 109), a fact of importance in seeking a safe water supply in communities where phosphatic fluorine-containing fertilizers are used extensively. The station observed that phosphate fertilizers prepared in an electric furnace were almost free of fluorine.

Effect of limestone on fluorine in phosphates.—A distinct repressive effect was found by the Tennessee Station to be exerted by limestone supplements upon the fluorine carried by barium fluosilicate, indicating that the fluorine content of phosphatic fertilizers may not be a problem when supplemental liming is practiced.

PLANT PROTECTION

The protection of plants against the ravages of insect pests and plant diseases, frosts, droughts, and other untoward circumstances is a leading feature of the work of the experiment stations as well as of the Department of Agriculture. Attention is here called to a few recent examples of the more general work of this kind by the stations. Others are noted in connection with the specific crops or products affected (pp. 22, 25, 26, 28, 30, 31, 33, 35, 37, 38, 39, 40, 41, 46, 54, 56, 57, 63, and 66).

INSECT PESTS

Prediction of insect outbreaks.—Prediction of insect outbreaks has been one of the greatest services rendered by some of the experiment stations to farmers in sections subject to sudden and devastating outbreaks of insects. On the basis of experimental work, the Montana Station, in cooperation with the Department, has been able to give such advance notices concerning grasshoppers and cutworms and has attempted a similar service with the beet webworm.

Radio waves to control insects.—The practical use of radio waves to control insects has been suggested as a possibility in investigations reported by the New Jersey Station. The station has found that insects may be killed by exposing them to lines of force prevailing in an electrostatic field of sufficient power to develop internal lethal heat. The station finds that insects respond so much more readily

to radio waves than do plants that in many cases the insects may be destroyed and the plants left unharmed by the same treatment.

The margin of safety between the energy level which will kill insects and damage plants at 3,000,000 frequency is very wide, but the margin of safety between the energy level which will kill insects and plants at 16,000,000 frequency is very narrow.

Trap lights for Japanese beetles.—The most attractive trap lights for Japanese beetles have been found by the New Jersey Station to be mainly those of the violet and ultraviolet spectrum. Traps equipped with such light were found in one case to catch approximately a quart of beetles in an hour.

An electric insect trap has been devised by the Massachusetts Station which not only kills insects but indicates the prevalence of insect pests and when to spray.

Similar work on trap lights has been done by other stations, including especially California, Indiana, and New York State.

Intercropping to control insects and other parasites.—Cotton, corn, turnips, and cabbage were found by the Tennessee Station to be mutually helpful when intercropped because of the encouragement given to the natural parasitic and predatory insect enemies of plant lice. On the other hand, tobacco and other plants with sticky leaves were found to act as natural traps for these allies of the farmer and therefore are not suitable in strip cropping.

Combating chinch bugs.—The chinch bug, referred to as the most destructive corn insect in the United States, is considered by the Illinois Station to be one of the most outstanding examples of the benefit derived by an insect from the present system of agriculture in the Middle Western States. "The principal reason for the tremendous abundance of chinch bugs in the Midwest area is that the system of farming in the area is almost ideal for promoting chinch bug abundance." To combat the pest, resistant strains of corn are being developed by the Illinois and other stations and various protective measures have been devised. The Illinois Station believes that—

by the proper arrangement of the crops on the farm and the proper balancing of the crops during chinch bug years, much can be done towards lessening damage. It is also possible to work out certain crop rotations that can be practiced with profit on most farms in the chinch bug infested areas and which will reduce damage by the bugs to a minimum.

The station says:

There is still much to be done in developing better and more effective methods of controlling this very serious pest. Better means should be found of combating the insect during the first brood while it is concentrated in fields of small grain. It is certainly still possible to improve our barriers used for combating them at the time of migration from the small grain to the corn. Aside from the development of resistant strains of corn, we are entirely lacking in a practical method for combating the insect while the second brood is being produced in our corn fields. We are also particularly in need of a control that can be applied to garden patches of sweet corn or to large fields of sweet corn grown for canning.

A chemically treated paper which appears to provide an effective barrier against chinch bug attacks has been developed by the Iowa Station. It is stated that 115 miles of this barrier have been used with good results in one county of the State. The new barrier operates on the same plan as the older oil and dust barriers. It con-

sists of a strip of creosote-soaked paper about $4\frac{1}{2}$ inches wide, placed upright in a groove and held in place by tamping soil against it on both sides.

From a comparison of water-gas tar from different sources and wood preserving creosote, the Ohio Station concludes that certain kinds of gas tar furnish a very effective barrier, but that because of the variability of the product it is by no means certain that other samples from the same source would give equally efficient protection.

Thoroughly disking a sorghum field as soon as possible after cutting greatly reduced the number of chinch bugs breeding in the field, in experiments reported by the Oklahoma Station. The greatest number of wintering bugs were found in Johnson grass, with sorghum stubble ranking second. Comparatively few bugs were found in native grasses, and alfalfa stubble, leaves, and trash had fewer of the insects than the native grasses. Bermuda grass, sweetclover, winter barley, winter wheat, and winter oats had very few bugs. The number of bugs found in any plant association was greatly influenced by its condition the previous fall and its nearness to infested crops. (See also p. 28.)

The gypsy moth.—The gypsy moth, one of the hardest and most destructive forest, shade, and orchard tree insects known, was introduced into Massachusetts from Europe about 66 years ago and, despite strenuous efforts by State and Federal agencies to eradicate it, has survived in Massachusetts and spread to other States. More than \$2,000,000 has been expended officially in Connecticut alone in attempts to exterminate or control the pest. Since 1891 the States, the Federal Government of the United States, and the Dominion of Canada have spent upward of \$41,000,000 in all the infested areas. The Connecticut (State) Station has recently published information about the various means, used by State and Federal agencies, of suppressing the pest or checking its advance. The chief of these are scouting and creosoting egg clusters, cutting and burning brush in some infestations, banding trees with burlap or tanglefoot and killing caterpillars and pupae in certain infestations, and spraying the more important infestations with lead arsenate, 5 pounds in 100 gallons of water.

Control of cereal-mill insects.—The control measures practiced almost exclusively against flour-mill insects are stated by the Montana Station to be fumigation with hydrocyanic acid gas and exposure to low temperatures during periods of subzero weather. Such methods were found to be effective when carefully carried out, but appeared to have certain inherent disadvantages which led to investigation of superheating as a means of control. The results showed that superheating, if properly carried out, can be made effective at a very reasonable cost, and some large cereal mills have installed heaters and are using them successfully for the purpose. Most satisfactory results were obtained with 5,373 British thermal units of heat per hour. To produce the necessary temperature 84,000 British thermal units per hour per thousand cubic feet of air space was required.

One of the large unit heaters tested was capable of delivering three times the amount of heat per hour when 10 pounds of steam pressure was applied. With a surface temperature of 150° F., a temperature of 120° was obtained to a depth of 6 inches in concrete

containers after 10 hours' heating. If the superheating was properly carried out, it was completed in 24 hours or less.

When a means of air circulation was provided and the ceiling temperature allowed to rise to 180° F., a floor temperature of 150° F. was obtained, well above that required in the successful use of this method. The air temperature gradient in the first half inch above the floor surface shows that, to be significant, temperatures must be taken in contact with the floor surface. If a thermometer is used to record the floor temperature, heat must be supplied for several hours after a lethal temperature has been recorded.

For satisfactory results it was necessary to remove all bags of flour and accumulations of cereal and the like from the mill before heat was applied.

Producing pyrethrum of superior quality.—Vegetative propagation has been found by the Tennessee Station to be a practical means of perpetuating highly toxic strains of pyrethrum. Results with seed have been uncertain and the product variable in toxicity.

Cadmium compounds as insecticides.—Cadmium oxide and hydroxide compared well with lead arsenate in toxicity to the tent caterpillar and other insects in experiments reported by the New Jersey Station. It is suggested that the cadmium compounds may prove to be an effective substitute for lead arsenate.

Other references to protection of crops or products against insect pests are cited on page 19.

PLANT DISEASES AND OTHER HAZARDS

References to protection of plants against diseases, drought, cold, and other untoward conditions are cited on page 19.

WEED CONTROL

Ways of preventing the losses caused by weeds in lower crop production, poorer quality of product, and reduced land values are receiving increased attention from the stations. An example of the greater activity in this field is that several stations in the Middle West and Northwest are cooperating with the Department of Agriculture in what promises to be an effective attack on a most serious pest, the bindweed (wild morning-glory). In contrast to much of the earlier and often rather elementary studies, recent investigations seek the key to weed control in the life history, growth habits, anatomy, and physiology of the weed as factors in its reaction to herbicides and cultivation.

Chemical weed control.—Chlorates have been found effective in control of perennial weeds with running rootstocks, as bindweed (wild morning-glory), quackgrass, and Canada thistle, by the Idaho Station and other stations. Chlorates have been applied more effectively in the fall than in the spring or summer. Many weeds were killed better by two applications a few weeks apart. Dry chlorate treatments, best applied to the soil by hand, served as well as spray or wet treatments. The chlorates were applied more cheaply in the dry form and the fire hazard was lessened. Excellent control of such spreading perennial weeds also has been obtained by the Ohio Station by applying a dry mixture of sodium chlorate and ground limestone with a common grain drill.

The use of sodium chlorate as a weed killer has been complicated by the fact that absorption by the soil may retard its action or make the soil poisonous for useful plants. Experiments by the California Station designed to kill weeds, especially wild morning-glory, by chlorate action through the plant, through the soil, and through both the plant and the soil, indicate the third method to be the most effective. Fall sprays, applied in a number of ways, were nearly all effective against the wild morning-glory. Winter treatments were effective as long as the bulk of the chlorate was applied early enough to be leached well into the soil, but late applications failed.

Comparing methods of controlling perennial weeds, the Utah Station showed that tillage, except for treatments delayed until blooming, was more effective and cost substantially less than chlorates. Wild morning-glory was most difficult to eradicate by tillage and was followed by Canada thistle and sowthistle, while with chlorates the order was reversed.

That weeds vary widely in response to poisons such as arsenic and sodium chlorate has been determined by the California Station. Chlorate has been especially toxic to plants grown on extremely light or extremely heavy soils, whereas arsenic has been most toxic on plants grown on the coarser soils. Arsenic and borax have shown antagonistic toxic effects, the latter not being toxic enough for value in weed control. Dry powdered arsenic trioxide was more effective than sodium arsenite solution.

Simple equipment developed by the California Station for use in connection with standard orchard sprayers for applying sulphuric acid solution in grain and other field crops for weed control, consists of an ejector and boom attached to the discharge side of the spray outfit. This device makes it unnecessary to pass the acid mixture through the pump or tank and overcomes the former problem of using acid-resistant pumps, tanks, piping, etc. Brass fixtures on the boom equipment prevent excessive corrosion.

Bindweed control.—Bindweed (wild morning-glory) (*Convolvulus arvensis*) is considered by the Kansas Station to be the most noxious weed in that State and one which is spreading at an alarming rate. The station found that bindweed can be killed on small areas by spraying with a solution of sodium chlorate or by salting. The solution of 1 pound of sodium chlorate to 1 gallon of water, best applied at the rate of 200 gallons per acre in August and 100 to 150 gallons in September and again in October, is recommended. Salt at the rate of 1 pound per square foot or 20 to 25 tons to the acre usually gave almost complete control with one treatment, but may destroy the productivity of the land for many years. Large infested areas were eradicated most economically by intensive cultivation accompanied by a smother crop.

The Nebraska Station, likewise, has found effective methods of exterminating bindweed, which it characterizes as the worst weed with which farmers have had to contend in recent years in Nebraska. The methods, clean summer fallow and treatment with sodium chlorate, both involve the loss of the land for crop production for 1 or 2 years. The station recommends the clean-fallow method for all large areas because the chief expense is labor. Thorough, frequent tillage for one and one-half seasons has eradicated well-established

stands. Sodium chlorate applied either in dry form or as a water spray has repeatedly been successful. The amount needed varies with soil fertility and texture and vigor of plant development; average conditions require about 500 pounds per acre. At 8 to 10 cents per pound the cost is prohibitive except for small patches and along fence rows and highways. Reinfestation through seedlings after eradication must be prevented by use of tilled crops and careful watching.

Eradication of whitetop.—Whitetop (*Lepidium draba*), one of the most serious perennial weed pests in Idaho, has spread widely throughout the irrigated areas. The Idaho Station found that the weed can be eradicated by two applications of chlorates made at 10-day intervals during blooming, the most effective combination being a 1-pound per square rod initial application followed by a 4- or 5-pound dosage. Single 6-pound sodium chlorate treatments in late fall have given 100-percent kills. The best method for eradication of large infestations includes two seasons of thorough tillage followed by 2 years of check-rowed crops.

FIELD CROPS

Advances made as the results of research with field crops at the experiment stations are shown in improved varieties of cereal, fiber, forage, tuber, and sugar crops, and tobacco; in the designation of suitable varieties of crops for specific conditions and purposes; in more effective methods of supplying the fertilizer and cultural needs of the several crops; in combating insect pests and plant diseases through resistant varieties, modifications of cropping practice, and improved chemical control methods; in the development of harvesting, storage, and handling methods insuring better qualities of the product; and in the determination of the numerous factors underlying the various quality characters in the several field crops. Conspicuous examples of such research accomplishments, especially those having more or less immediate practical application, and also significant progress results from investigations closely related to the Nation-wide movement toward increased production of pastures, meadows, and other forage, are given in the following pages.

COTTON

Fertilizers for cotton.—Field tests in eight localities, made by the Alabama Station during 5 years to determine the best grade of fertilizer for corn and cotton when grown on the same land in alternate years, indicated that the mixture best for cotton furnishes nitrogen 36 pounds, phosphoric acid 48 pounds, and potash 24 pounds per acre, which may be supplied by 600 pounds of a 6-8-4 fertilizer, or by 600 pounds of a 4-8-4 fertilizer and a side application of 75 pounds of sodium nitrate or its equivalent.

As a result of 6 years' work in six locations, the Georgia Station recommends for cotton on average soil 400 pounds per acre of an 8-8-8 fertilizer or its equivalent, such as 400 pounds of an 8-4-4 fertilizer plus a top dressing of 16 pounds each of nitrogen and potash.

Effect of potash fertilizers on cotton wilt and rust.—In further studies of the effect of potash-containing fertilizers on cotton wilt and rust, the Arkansas Station obtained additional data confirming previous conclusions that in the presence of a low initial potash content of the soil, the use of nitrates or phosphates either alone or in combination, but without potash, has resulted in a severe "rust" or potash-hunger condition and in a greater incidence of the cotton wilt disease. The greater vegetative growth early in the season resulting from the use of phosphates and nitrates without potash is believed to cause a definite unbalanced nutrition of the plant which may result in even more "rust" and cotton wilt than when no fertilizer is applied.

Gypsum as a supplement to concentrated cotton fertilizers.—Injury to cotton seedlings and excessive loss of soil fertility following the use of certain concentrated fertilizers, especially those containing ammonium phosphate but no lime, has been observed by the North Carolina Station in experiments on sandy soils. Addition of relatively small amounts of gypsum to the concentrated fertilizer brought the efficiency of the latter up to that of fertilizers commonly used, whereas indications were that the gypsum content of ordinary fertilizers may be excessive when heavy applications are used, and that fertilizers containing less gypsum might be equally effective and would cause less loss of magnesium and potassium from the soil by leaching. In general, the experiments suggested that the concentrated fertilizers commonly used will equal and sometimes surpass ordinary fertilizers if properly supplemented and distributed (that is, not in too close contact with the seed).

Growing cotton under irrigation.—In its experiments with cotton under irrigation in the Wichita Valley, the Texas Station obtained yield increases averaging about 11 percent from fertilizers, but such increases usually were unprofitable. Manure returned the largest gains and its moderate use is advised because it also improves the physical condition of the soil. Planting tests indicated from April 25 to June 15 and from 6- to 24-inch spacing in the row for best results. Heavy irrigations with from 2 to 3 acre-inches of water at longer intervals gave better results than frequent light applications.

For good stands of Acala cotton grown on Gila clay adobe soil, the New Mexico Station found that planting should precede irrigation. An interval of from 5 to 6 weeks between the first two irrigations resulted in good growth conditions. The wide adaptation of cotton as to water was indicated by the similar yields from four or five applications and but slightly higher returns from twice as many irrigations. The length of lint was determined largely by moisture conditions early in summer and apparently was not affected by later water-stress conditions. Indications were that withholding water late in the summer would hasten maturity, and vice versa, continuing irrigation until late in September could delay maturity with an increase in immature bolls.

The Arizona Station reports that in recent years domestic cotton mills have largely avoided the use of upland cotton produced under irrigation in the Southwest, claiming that too much of the so-called irrigated cotton is wasty and forms neps (small knots of tangled fibers), which make it difficult to produce smooth-running yarn.

Thin-walled fibers were found to be more subject to nep formation than the thicker-walled fibers. The station found that the excessive production of thin-walled fibers is due to rapid growth in height during the period of most rapid fiber-wall thickening, and that a combination of plant selection, fertilizing, and irrigation which reduces growth may provide a means of producing lint better adapted to spinners' requirements.

Boll weevil control.—The Oklahoma Station has found that the distribution of over-wintered boll weevil has no relation to nearness of woods, but that weevils tend to concentrate in that part of the field nearest to alfalfa. In over-wintering studies the station found that the freezing range varied from -5.5° to -18.75° C., and the undercooling range from -6.87° to -21.87° . Death did not always follow when the boll weevil was undercooled, since under laboratory conditions 11.7 percent of the boll weevils recovered after undercooling and resumed normal activities on greenhouse cotton plants.

Cotton bollworm hosts.—The Arkansas Station finds that the cotton bollworm, although having a wide range of host plants, develops more rapidly and in greater numbers on corn and some legumes than on other hosts available early in the season. For this reason, large acreages of corn and legumes in cotton territory will favor abundance of bollworm.

Picking v. snapping cotton.—In a comparative study of picking versus snapping cotton, the Oklahoma Station found that picked cotton averaged higher in grade and longer in staple and brought farmers higher prices than snapped cotton. However, other factors, the influence of which was not measured, may be of some importance in modifying these results. For instance, cotton can be harvested more rapidly by snapping which enables a smaller labor force to harvest a given amount of cotton and with less danger of weather damage.

Improving quality of cotton.—Uniformity, a most important character of cotton fiber for spinning purposes, according to the Arizona Station, has received relatively little attention from the cotton breeder until recent years. The use of a sorter devised by the station for the study of uniformity appears to furnish reliable data as a basis for breeding for this purpose.

The New Mexico Station reports progress in developing two strains of cotton outstanding in uniformity and strength of staple and has thus added greatly to the profits of New Mexico cotton growers. This station, cooperating with the Department, has found the average staple length of cotton grown in that State from 1928-32 to be $1\frac{3}{32}$ inches. This has been made possible through the production and distribution of pure seed of one variety, Acala. Cotton of still better staple length was grown in 1933 and 1934.

The North Carolina Station, cooperating with the Department of Agriculture, found the percentage of fifteen-sixteenths-inch and longer cotton grown in North Carolina in 1934 to be 73.4 versus 20.3 percent in 1928, indicating marked improvement in staple length. The better varieties stapling 1 to $1\frac{1}{16}$ inches have produced as high as or higher yields than cottons with seven-eighths-inch or shorter staple and greater cash returns, due to premiums for the longer staple.

One-variety community cotton production.—Since 1927 the Georgia Station has been cooperating with the Department of Agriculture and other agencies in developing one-variety community production of cotton. A survey of results obtained in 1934 shows an increase of \$7.13 in value per acre from following this practice, with a pronounced improvement in the staple length of cotton grown. In 1929, 21 percent of the cotton grown in Georgia was shorter than seven-eighths inch, and only 10 percent was fifteen-sixteenths inch and longer. In 1934, 99 percent of the cotton grown in five communities was 1 inch or longer.

Price-quality relationships in cotton markets.—Studying price relationships in the case of 53,000 bales of cotton sold in 24 markets in Texas during the past 7 years, the Texas Station found decided inequalities and discrepancies in prices received by growers. Thus, prices paid growers for the higher qualities and for the lower qualities of cotton did not differ widely from an average price. The average price paid growers in the various farmers' markets after the effect of location had been eliminated was found to conform rather closely to the difference in average quality of cotton in those markets. The general effect of a low-average quality in a farmers' market in depressing the price of specific qualities and of a high-average quality in raising the price of specific qualities enables a grower with high-average quality to sell to better advantage in a farmers' market of high-average quality than in one of low-average quality.

CORN

Germination of seed corn.—Seed-corn ears harvested by the Iowa Station at intervals from the time the kernels were in the soft-dough stage with 60 percent of moisture until they were fully mature were compared to determine their relative value when planted in the field. Although the corn harvested in the soft-dough stage germinated satisfactorily and more quickly than the more mature kernels, equally as good stands were not obtained in the field, and plants from the immature kernels did not grow as rapidly in the early part of the season. Because of its poorer stand the immature seed did not produce as well as mature seed. When planted thickly and the plants thinned to produce equal stands, the yields obtained from seed picked at different stages of maturity were practically equal.

Cultural practices in corn production.—During its prolonged cultural experiments with corn, the Nebraska Station found that early spring plowing and also weed control resulted in good yields. Yields were similar from the most productive listing and surface-planting practices. Surface-planted corn gave about equal yields whether checked or drilled. Some departure from standard planting rates and considerable variation in uniformity of stands could occur without materially affecting acre yields. Material benefit was not obtained from treating seed with any commercial seed-corn disinfectant. It was observed that whatever root injury accompanies normal cultivation is not likely to prove harmful.

Corn-planting methods.—The basin planting of corn, being studied by the Iowa Station cooperating with the Department of Agriculture,

helps to check run-off and erosion, promotes storage of water in the subsoil, and may reduce markedly labor and power requirements for growing corn. The slow early growth of basin-listed corn compared with surface-planted corn was found due to a lack of available nitrogen.

Planting corn under irrigated conditions, the Colorado Station obtained best results with four plants per hill in hills 3 feet apart in 3.5-foot rows and spacing of 6 to 9 inches between plants in rows of drilled corn.

Maintaining high corn yields.—An average yield of 73.6 bushels per acre of corn has been obtained by the Ohio Station in a 29-year rotation experiment on poorer-than-average Ohio soils through early plowing and good seedbed preparation and culture, disease-free varieties, including clover in the rotation, regular but moderate manuring and fertilizing, and keeping the land free from weeds.

For corn in a 2-year rotation with cotton, the Alabama Station found that on average soils well fertilized with phosphorus and potash for other crops, 36 pounds of nitrogen per acre as 225 pounds of sodium nitrate or equivalent, is the only fertilizer needed. Under certain conditions phosphate may also be applied profitably.

Insect pests of corn.—From 50 to 75 percent of the damage to corn, wheat, and oats caused by chinch bugs, estimated at more than \$40-000,000 in Illinois in 1934, according to the Illinois Station, could be avoided by using control methods proved to be effective. This can be done, the station points out, by growing chinch bug-proof crops, proper crop rotations, growing certain crop mixtures, using varieties resistant to chinch bugs, using barriers and traps when the bugs migrate from small grain to corn, and by winter burning the favored hibernating quarters.

Effective control against chinch bugs consists of throwing a barrier across their line of march, the Michigan Station finds. The best barrier tested was made by turning a furrow toward the field to be protected, dragging to smooth the furrow slice, digging post holes 20 inches deep every rod, and then laying down a thin ribbon of creosote oil at the top of the furrow slice and touching each post hole. Bugs accumulating in the post holes are killed by pouring half a cup of kerosene upon them. (See also p. 20.)

Strains of hybrid corn highly resistant to damage from chinch bug attack and also high in yield and quality of grain have been developed cooperatively by the Department of Agriculture and several experiment stations, especially in Illinois, Kansas, and Oklahoma. A chinch bug resistant hybrid corn developed by the Illinois Station with such cooperation in 1934, one of the worst seasons in the history of the station for chinch bugs, drought, and other unfavorable conditions, yielded 90 bushels of sound corn per acre, more than half again as much sound corn as local open-pollinated corn produced in station tests.

Hail injury to corn.—Corn yields were reduced when the Iowa Station stripped, severely shredded, and bruised corn plants to simulate hail injury as nearly as possible. Total leaf removal at weekly intervals from four-leaf to first tassel stages reduced the yield in almost direct proportion to the percentage of leaves unrolled at the time of injury. Yield reduction ranged from 9 percent during early

June to 100 percent about July 20, at the pretassel stage, decreasing gradually after the completion of fertilization and ending with a 5-percent reduction in yield on September 7, when the corn was nearly mature. Severe shredding of the leaves and removal of one-third and two-thirds of the leaves showed the same results. Leaf and stalk injury at all stages of development reduced the kernel development but little except where a large proportion of leaf area was removed either just before, during, or following the tasseling-silking period. Injury during the rapidly developing period before tasseling increased the percentage of smutted plants somewhat.

Leaf removal and injury before and after the critical stage when the ear shoots of corn were just emerging, the Illinois Station observed, was comparatively less harmful and became very slight in the dent stage. Grain quality, as indicated by test rate per bushel, was lowered most by leaf removal when developing grains were in the blister stage, although rotting of ears was worst when the bruising action of simulated hailing occurred in the early milk stage. When the sides of the blades were torn from the midribs but left intact to the base, the yield was 75 percent higher than with complete blade removal. Yield reductions at all growth stages corresponded roughly with the percentage of leaf area removed, suggesting that loss from hailstorms might be estimated from a determination of the leaf surface destroyed.

Agricultural and industrial demand for corn.—Corn production has been decreasing in the United States and increasing in other countries. The Iowa Station finds that from 1900 to 1920 the United States corn crop averaged 68 percent of the world crop, but has been declining since the World War, reaching 55 percent in 1933. From 1920 to 1935, consumption of corn by horses and mules decreased about 180 million bushels. Consumption of corn by hogs and by cattle on farms increased 120 and 80 million bushels, respectively, from 1910–14 to 1924–29. The consumption of corn by makers of corn meal, corn flour, and hominy grits has declined from 200 million bushels before the war to 40 million (2 percent of the crop) in 1932. Corn used by makers of cornstarch, corn sirup, corn sugar, and byproducts has been slowly increasing, until now it accounts for 3 or 4 percent of the crop. Makers of distilled spirits and cereal beverages consumed, in the peak year (1917), 34 million bushels, about 1.3 percent of the crop, but a considerable reduction has taken place since then.

WHEAT

Wheat growing in Montana.—Economic changes in the wheat-growing area of Montana have been studied by the Montana Station with the aim of pointing out desirable adjustments. Because of the generally greater intensity of production in the wheat area, investments in buildings and farm machinery are generally higher than in the State as a whole. Effects of favorable and unfavorable factors bearing upon agricultural production are shown clearly in the changes in number of farms and acreages per farm during the decade from 1920 to 1930. A definite trend toward larger farm units in Montana

was evident, especially in the wheat area where mechanization of wheat production has been the largest single factor. This general trend verifies the indication of earlier studies by the station in regard to the size of farm organization as related to its efficiency.

Improved varieties of wheat.—Outstanding improvements in wheats, the Washington Station reports, have been in greater winter hardiness, stiffer straw, higher yielding ability, nonshattering chaff, and smut resistance. In certain restricted areas wheats particularly adapted to escape frost and hot winds have been emphasized. In the system of breeding, testing, increasing, and distributing worked out by the station, improved strains may quickly become predominating wheats. Thus, within the last decade Albit has become the leading winter wheat and Federation the leading spring wheat in large sections of the western territory, Early Baart the leading dry-land spring wheat, Turkey the predominating winter wheat in the drier areas, and Dicklow, Federation, and Jenkin are leaders under irrigation. Hymar, a new hybrid wheat (Hybrid 128 \times Martin) produced by the station, working in cooperation with the Department of Agriculture, is expected eventually to replace Albit wheat.

The severe rust epidemic of 1935 in the hard red spring wheat region, says the North Dakota Station, served to confirm results which had been anticipated in the breeding of wheat varieties resistant to stem rust. New hybrid selections, which earlier had been promising in face of light epidemics, were found to be highly resistant in the epidemic of 1935, perhaps the most severe that has ever invaded the spring wheat region. In addition to resistance many of the new hybrids showed excellent yielding capacity combined with resistance to extreme heat. This breeding program, covering a period of 20 years, has been an excellent example of cooperative scientific work between experiment stations and the United States Department of Agriculture. By the free interchange of information and material vastly more rapid results were secured than otherwise would have been possible. Yielding capacity and quality of grain, and resistance to stem rust, to heat, and to drought have been secured and united into single varieties by the varied use, in the main, of the following basic varieties of wheat: Marquis, Kota, Iumillo durum, Vernal emmer, Kanred, and Florence. The first and last of these were produced earlier by breeding. Where 20 years ago no rust-resistant common wheat, of the 42 chromosome group, was known to exist, today there is really a wealth of new hybrid wheats which showed practically complete resistance in this last epidemic. Breeders who have produced these wheats have every reason to believe that this resistance will be maintained in the future. Already one new wheat of this type, Thatcher, has been released by the Minnesota Station, while other hybrids are under increase at other experiment stations.

Oro and Rio wheats are examples of smut-resistant, high-yielding varieties introduced and developed by the Oregon Station in cooperation with the Department of Agriculture. These wheats also were found to possess other desirable qualities equal or superior to present commercially grown hard red wheats which they are expected to replace in eastern Oregon as soon as enough seed is available. The introduction of Federation and Hard Federation spring wheats, Markton oats, and Meloy barley, all first released and distributed by

the Oregon Station and now the standard varieties in eastern Oregon, has increased the farmers' incomes many thousands of dollars through increased yields, less smut, and a better quality product.

The acreage of Relief wheat, which is resistant to most forms of bunt or stinking smut occurring in Utah, is, the Utah Station reports, increasing rapidly in that State. The station, cooperating with the Department of Agriculture, has other promising wheats, including selections of a Hope \times Federation cross, which show resistance to both loose smut and bunt, and a spring selection of a Dicklow \times Hard Federation cross which has been released for preliminary trial. Three new winter wheats being multiplied for trial by farmers in the coming year have all shown high resistance to all forms of smut isolated in Utah and appear desirable in other respects.

Cheyenne wheat, developed by the Nebraska Station, is a consistently high-producing variety which is currently being grown on approximately 100,000 acres.

Through cooperation with well-trained experienced men in Federal, State, and commercial laboratories, the Kansas Station has made cereal chemists of the leading milling firms familiar with the characteristics of a new variety of wheat before distribution to the farmers. This procedure was followed with great advantage with the Tenmarq variety of wheat. It has resulted in discarding several strains which were promising in agronomic characters but had some serious defect in quality from the miller's standpoint.

Use of fallow in growing wheat on dry lands.—As a result of 19 years of crop rotation and tillage experiments on dry land, the Montana Station cooperating with the Department of Agriculture has found that alternate fallow and crop has had an advantage over other methods for the small-grain production. During periods of extreme drought, when there were more than 2 consecutive dry years, yields of small grain on fallow were often not much larger than on other preparations, whereas in more favorable years summer fallow justified itself by the much greater increase in bushels per acre. During the last few years a decided improvement in cultivating machinery has resulted in a reduction in the cost of fallow. Fall plowing, left rough during the winter, and May plowing of fallow gave about equal results, all surpassing July plowing. The most advantage was derived from subsoiling. Soil blowing has been reduced by strip farming with strips about 200 feet wide.

Irrigation of wheat.—Economical use of water, a problem in the irrigated regions, is constantly becoming more acute as the amount of available water per acre decreases and the area of irrigated land increases. The highest yield and most efficient use of water for normal growth of Marquis wheat, the Colorado Station found, was obtained by applying 6 inches of water at the jointing or heading stage.

Fertilizing wheat.—In the New Jersey Station's experiments, wheat grown on land heavily fertilized for potatoes for 10 years has averaged 50 bushels per acre. Wheat following several years of potatoes which had received 250 to 1,000 pounds per acre of a 15-30-15 potato fertilizer showed a gradual rise in yield as the fertilizer increased up to 750 pounds per acre. The Ohio Station finds that top dressing winter wheat in January or February with 4 to 6 tons of straw

manure materially improves stands of both legumes and timothy following wheat and enables seedlings to survive spring drought.

Pasturing winter wheat.—The Kansas Station cooperating with the Department of Agriculture finds that when properly managed, a good growth of wheat may be grazed moderately during winter without reducing the grain yields, and that under extra favorable conditions for growth the yields may be increased from grazing. The station considers winter wheat pasturage a byproduct in seasons of adequate rainfall and on well-cultivated fields in which subsoil moisture has been stored. It is produced at no extra expense, is a good feed, and conserves dry feeds for emergency uses. The Ohio Station has found that spring grazing of winter wheat with sheep greatly improves stands of legume-timothy mixtures following the wheat.

The quality of wheat.—Analyses made by the New Mexico Station showed that certain varieties of hard red spring wheat grown under irrigation are usually high in protein and over the 7-year period studied (1928–34) would have received an average premium of about 7.5 cents a bushel on the Minneapolis market. Although the hard red winter wheats did not approach high protein under irrigation and may not be so desirable for the warmer irrigated sections of the State, they were high in protein in the dry-farming area, and for the 7-year period would have qualified for premiums of 2 to 17 cents per bushel on the Kansas City market. All of these wheats average 4.6 percent lower in moisture than the wheats of moist climates.

Studies of the quantity and quality of protein of soft winter wheat by the Ohio Station showed decided correlation between viscosity and baking quality. Decided differences were noted in quality of wheat from different sources. Applications of fertilizers produced wide variations in quantity of protein. Nitrogen, potassium, and phosphorus as fertilizers decreased the amount of protein, the effect of phosphorus being most pronounced.

Further efforts to improve the wheat meal fermentation test as a reliable and simple means of determining the quality of wheat produced in breeding work, especially with hard wheats, have been made by the Kansas Station. The value of the test for soft wheats has been demonstrated but additional proof of the reliability of the test for hard wheats is needed.

Additional evidence that gluten strength is a hereditary quantitative character measured accurately in winter wheats by the fermentation test has been obtained by the Indiana Station. The same station also concluded that cold resistance in winter wheat is inherited like other quantitative characters.

OATS

Oats in the Northwest.—Support, a new winter oat variety developed at the Oregon Station in cooperation with the Department of Agriculture, which ripens 7 to 10 days earlier than Gray Winter oats, is of promise for growing with annual viny legumes, such as vetch, for forage. It has decidedly surpassed Gray Winter at the station in grain yields.

Oat production in Washington, the Washington Station reports, reached its peak in 1910, dropping during the next 15 years to almost the 1900 level and gradually increasing since 1930. This drop in oat

production is accounted for in measure by decline in the number of horses and mules, replaced by tractors. The increase in oat production during the depression may be due to the return of these animals in the oat sections. Markton, the variety recommended for eastern Washington, from results of the station's tests, has immunity from known forms of oat smut, good yields, high bushel weight, low percentage of hulls, and medium-early maturity. Victory is indicated for the lowlands of western Washington because of its high yield and stiff straw, although Markton yielded well on the uplands there and has the advantage of immunity from smut. Gray Winter, the oats most commonly used for fall seeding, can be sown alone or with peas or vetch for hay and silage.

BARLEY

Winter barley.—The Missouri Station has found that winter barley provides an abundant and nutritious pasturage as well as good yields of excellent grain. The favorite varieties are ready for harvesting in late May or the first days of June, about 2 weeks ahead of rye, 3 weeks ahead of spring barley, 3 to 4 weeks ahead of wheat, and 4 to 5 weeks ahead of oats. Its earliness enables winter barley to escape in large measure damage from chinch bug and spring drought.

RICE

Reducing sterility in rice.—Finding that the percentage of sterility, the growth, and the final yields of rice can be controlled as desired by varying the concentration of various necessary nutrient elements, the Arkansas Station concludes that sterility is not due to a bacterial or fungus disease but is purely a physiological condition and largely comprises external conditions of nutrition.

Root rot resistance of rice.—Short-grained varieties of rice were found more resistant to stem rot, caused by *Sclerotium oryzae* (*Lepidosphaeria salvinii*), than medium- or long-grained varieties, in investigations by the Arkansas Station, cooperating with the Department of Agriculture. Since short-grained varieties are not grown extensively in Arkansas, an attempt is being made to develop medium- and long-grained resistant varieties by crossing the commercially grown medium- and long-grained types with the short-grained types. A number of hybrid selections from such crosses appear to be more resistant than the medium- or long-grained parent.

POTATOES

Improvement in potato varieties.—Nittany Cobbler, a new early-maturing potato developed by the Pennsylvania Station and introduced in 1935, is stated to be highly resistant to mild mosaic which causes heavy losses in Pennsylvania and elsewhere.

Several close relatives of the cultivated potato that are immune to late blight, obtained from central Mexico, through the Department of Agriculture, are being used by the New York (Cornell) Station for crosses with the common potato to secure, if possible, blight-immune hybrids which may prove of commercial value.

Certified seed potatoes.—Approximately two-thirds of all the certified seed potatoes now grown in New York has come from the New York (Cornell) Station's hill-unit selections, and all registered-certified stocks are from this source. This is one of the practical results of potato-breeding work carried on in cooperation with the Department of Agriculture, consisting of isolation of improved strains by hill-unit selections; testing seedlings resulting from potato breeding at Presque Isle, Maine; and breeding for yield, quality, resistance to diseases and insects, heat and drought tolerance, and uniformity.

Decided progress in producing seed potatoes free from virus diseases by use of cheesecloth cages to prevent insect transmission of the diseases is reported by the Maine Station. The Maryland Station demonstrated that practically disease-free seed stocks of McCormick can be developed and maintained and that prolific seed stocks practically free from diseases and mixtures can be developed and maintained by tuber-index planting in the spring, followed by tuber-unit planting in the fall on the Eastern Shore, or tuber-unit planting at high elevations.

Dry land versus irrigated seed potatoes.—Comparative yields produced from dry land and irrigated Triumph seed in Nebraska Station tests and in similar tests by seven cooperating stations in the South indicated that production under irrigation does not impair the seed value of stocks that are free from virus diseases. Appraising the seed value of potatoes grown in different crop rotations with irrigation, this station observed that crop conditions favoring high yields, as irrigation combined with long rotations and manuring, do not impair the value of the tubers for seed. The Nebraska Station, working in cooperation with the Department of Agriculture, found that production of seed potatoes on dry land in the central Nebraska district may be feasible if good seed stocks are grown by proper methods in isolated fields. The greater precautions necessary make seed potato production under irrigation seem less desirable for the season.

Planting practices for potatoes.—Seed and planting practices indicated from Ohio Station experiments with potatoes include keeping seed warm for early planting and preventing it from sprouting or wilting for late planting, greening it under humid conditions, protecting cut seed from sun and wind, using small whole seed if available, leaving heavy soils loose after plowing, placing fertilizer at the side of but not in contact with the seed, and planting from 3 to 4 inches deep, covering lightly, and gradually filling furrows as young plants emerge.

For potato production in north Georgia, the Georgia Station recommends that seed 1.5 to 2 ounces in weight be planted 12 inches apart in 3.5-foot rows, in well-drained loose soil in which commercial fertilizer high in phosphorus is drilled at the rate of 600 to 1,000 pounds per acre and thoroughly mixed with the soil.

Previous green sprouting of potato seed promoted earliness of emergence and a more early growth of both foliage and tubers in the New York (Cornell) Station's experiments, but did not affect the stand. The most important economic result of the studies was that yield per acre of marketable-sized tubers was significantly increased

by green sprouting. The highest set of tubers was obtained by planting from 2 to 4 inches deep, while planting at a depth of 4 inches gave the highest average yield of No. 1 potatoes.

Fertilizers for potatoes.—On major potato-producing soils in the eastern Kansas River Valley, the Kansas Station found that a combination of nitrogen and phosphoric acid at the rate of 150 pounds per acre of 15-30-0 fertilizer produced a profit more consistently than any other fertilizer tested, although 200 pounds of 11-48-0 per acre was most profitable in years of high yields. The station points out that commercial fertilizers should be applied in a band on each side of but not touching the set, and that use of commercial fertilizers should not eliminate the growing of green-manure crops in rotation with potatoes.

Fertilizer experiments with potatoes grown on different soil types and under different conditions were reported on also by the Connecticut (Storrs) Station, which obtained its largest yields from the use of 100 pounds of nitrogen, 160 pounds of phosphoric acid, and 140 pounds of potash. It calls attention to the fact that the crop now is grown commercially on many farms that formerly grew tobacco or other crops which presents additional problems in wide range of soil type and history of treatment. The station is cooperating with the Connecticut (State) Station in experimenting at Windsor with potatoes on old tobacco land.

Effect of soil aeration on potatoes.—By liberal manuring and frequent use of green manures the Ohio Station found that the yield of potatoes could be nearly doubled on silt loam and heavier soils. By further aerating the soil directly under potato rows by shallow tile lines open at both ends, yields of 400 bushels per acre have been obtained. The station finds that the potato plant is peculiarly sensitive to soil aeration, and that insufficient aeration may be often a limiting factor in potato yields on silt loam and heavier soil types.

Liming potatoes.—A study of the effect of different kinds of liming materials on the yield of potatoes, the soil reaction, and replaceable bases, led the Virginia Truck Station to the conclusion that it is desirable to lime very acid soils and that finely processed limes act more quickly in the soil than coarser materials. After a period of about 2 years, however, all limes used produced about the same change in soil reaction. The dolomitic limes gave the largest returns in yields. From its experimental work the station makes definite recommendations for the liming of the principal soil types of eastern Virginia.

Control of brown rot of potatoes.—Almost complete control of brown rot of potatoes by application of inoculated sulphur and agricultural limestone between crops is reported by the Florida Station. Sufficient sulphur was applied to the soil to adjust the reaction to pH 4 or lower to kill the causal organism, *Bacterium solanacearum*. After a minimum period of 5 months, limestone was applied to raise the reaction to pH 5 or above for normal potato growth. Soils with a reaction of approximately pH 5 required 800 pounds of sulphur and 2,000 to 3,000 pounds of limestone per acre.

An improved potato harvester.—A tractor-drawn potato harvester, being developed during several years by the Pennsylvania Station and now ready for commercial use, eliminates much of the drudgery

of hand-digging. With this machine three men can dig, grade, and load 1,100 bushels a day.

Storage of seed potatoes.—For the storage of seed potatoes the New York (Cornell) Station finds a constant temperature of 40° F. better than one of 35°, and 35° better than a constant temperature of 32° maintained up to the time of planting. The seed value of potatoes stored at different temperatures depended primarily on the size of sprout developed and secondarily on whether desprouting was performed. A sprout as large as possible, but not protruding so far out of the eye that the tip may be damaged badly or which is protected from injury by greening, is the most desirable character of healthy seed tubers at planting time.

Growing a fall crop of potatoes.—Oklahoma grows a large crop of potatoes which, the Oklahoma Station says, cannot be kept in storage longer than 2 or 3 months. As a result, most of the potatoes required during the winter must be secured from other sections, requiring payment of a high toll in freight rates. The station reports progress in finding a solution of this problem by growing a fall crop of potatoes. Chemical treatment of the tubers to break the rest period so that they will germinate, holding the spring seed stock in cold storage until planting time in August, use of fallow for the retention of soil moisture, and planting new varieties with a short rest period, are phases of the investigation which are yielding encouraging results. The Alabama Station gives practical suggestions for growing the fall crop of potatoes, based largely on its experiments, especially on varieties and seed sources, methods of shortening the rest period and hastening sprouting, planting dates, and soil, cultural, and fertility needs.

Potato marketing.—A central potato sales office organized by New Jersey growers with the aid of the New Jersey Station has been successful in aiding the growers to secure a better price for their potatoes. The central sales organization was able to secure \$1 per bushel for New Jersey growers, whereas without this help the current selling price would probably not have exceeded 75 cents per bushel. Growers have been urged to dig and market slowly and thus prevent undue depression of the market.

Consumer preferences for potatoes.—About 55 to 65 percent of the 24,000,000-bushel potato crop of Wisconsin competes in the market with potatoes from other sources, particularly from States further west. The Wisconsin Station points out that restricted purchasing power during recent years has lessened consumers' demand for the more expensive potatoes shipped in from a distance, and many, therefore, have continued to use the much cheaper Wisconsin-grown potatoes. In the course of efforts to assist growers and distributors to correlate their production and marketing activities, the station investigated consumption habits, customs, needs, and preferences of the larger markets, and found that important reasons for consumers' rejection of potatoes include lack of uniformity in size and appearance; unclean, and diseased and mechanically injured condition; poor grading and packing, immaturity, softness, and poor keeping quality; and poor cooking quality. The station suggests, therefore, not only production of potatoes of better quality but the organization of better methods of distribution.

TOBACCO

Tobacco growing in Connecticut.—Through many years the Connecticut (State) Station, cooperating at times with the Department of Agriculture, has brought the aid of science to the wrapper and binder tobacco growers of Connecticut by developing improved strains of tobacco, and demonstrating the soils best suited to tobacco, and best methods of fertilizing and culture, of protection against insect pests and diseases, and of curing the product. It has summarized results of all this work in a recent bulletin which is a complete compendium of scientific and practical information on the culture of tobacco in Connecticut.

Effect of shading tobacco.—Shade cloth over a tobacco field reduces the intensity of sunlight which in turn affects the quality of leaves. Therefore, the Connecticut (State) Station measured light intensity under the shade tent and observed that shading reduced the light intensity from 34 to 64 percent, depending on light intensity in the open. The leaves grown under shade are thinner, longer, and broader, and the veins are smaller, all desirable characteristics for cigar wrappers. The chemical composition of the plant also is modified by shading; shaded plants are higher in total nitrogen and lower in carbohydrates than corresponding sun-grown plants.

Fermentation of tobacco.—Although "fermenting" or "sweating" of tobacco has been practiced for more than a century without marked improvement in method or results, the Wisconsin Station, cooperating with the Department of Agriculture, recently brought to light new information on fermentation. The research demonstrated that certain fungi which normally occur on tobacco can, in the presence of adequate moisture, induce changes comparable to normal fermentation. Bacteria did not produce similar action. Whether these fungi are essential rather than incidental to the fermentation process under practical conditions is under further inquiry. The work also indicated that tobacco should be kept at not more than 113° F. for best results in fermentation. Little or no active generation of heat occurred above this point. A moisture content sufficient to permit proper fermentation and yet not likely to result in damage appeared to be a critical factor in securing best results.

Breeding tobacco for black shank resistance and quality.—Seed of superior varieties of tobacco resistant to black shank disease, developed by the Florida Station, are being supplied to shade-tobacco growers, thus making a definite step toward standardization of varieties for the Florida shade-tobacco industry.

Weed fallow in the cropping system for tobacco.—Tobacco grown after natural weed fallow by the Maryland Station, cooperating with the Department of Agriculture, made very satisfactory yields, quality, and acre value. Weed fallow promotes a quick start and a rapid uniform growth of tobacco plants. One year of weeds between successive tobacco crops gave excellent results during 10 years, although recent indications were that 2 years of weeds between tobacco crops would prove better over a longer period. Satisfactory yields of tobacco also could be maintained by using legumes and fertilizer, best results being obtained from hairy vetch as a cover crop with continuous tobacco and red clover in a 3-year rotation including

wheat. Average leaf quality obtained with red clover in the rotation decidedly surpassed that where other legumes were used.

Tobacco fertilizers.—On the basis of their extensive fertilizer experiments and experience, the Virginia, North Carolina, South Carolina, and Georgia Stations, and the Department of Agriculture cooperated in recommending for the 1936 crop of bright flue-cured tobacco on the heavy or more productive soils, mixtures containing 3 percent of total nitrogen, 8 of phosphoric acid, and 6 of potash, with 2 percent less of phosphoric acid for light or less productive soils, the mixture being applied at the rate of 700 to 800 pounds per acre on heavy soils and 800 to 1,000 pounds per acre on the light soils, preferably mixed thoroughly with the soil in the row before ridging, or applied in bands to the side of the rows, within 10 days before transplanting. Fertilizers should carry 2 percent of magnesia (MgO), one-half of which is water-soluble, a minimum of 6 percent of lime (CaO), 2 percent of chlorine, and a certain amount of sulphur, in form of approved carriers. The mixture for dark tobacco, nitrogen 3 percent, phosphoric acid 10, and potash 4 to 6 percent, was to be used at the rate of 600 to 1,000 pounds per acre. For plant beds a 4-8-3 fertilizer from the same sources, practically free from chlorides and including 1 percent of available magnesia, was advised.

SUGAR CROPS

Sugar-beet growing in the intermountain region.—Methods best suited to sugar-beet production in the intermountain region are being sought by the Colorado Station, cooperating with the Department of Agriculture. The essentials developed include early planting, cultivation limited largely to weed control, early irrigation with frequent light irrigations during the summer and one late application in the fall, and 8-inch spacing of plants.

Sugar-beet seed production.—The sugar-beet industry in the Southwest was further aided by the New Mexico Station to the extent that there was harvested in 1934 1,000,000 pounds of seed valued at \$100,000. The station has cooperated with the Department of Agriculture in increasing seed of strains of sugar beets with a high degree of resistance to curly top, which is one of the main hazards of the industry.

Sclerotium rot of sugar beets.—*Sclerotium rolfsii* rot of sugar beets is reported to be rapidly assuming economic importance in two of the main sugar-beet growing areas in central California. The California Station finds that prevention of return of infected screenings from the loading stations has helped to curb its spread. Addition of anhydrous ammonia to the irrigation water also reduces losses and increases tonnage. Mechanical washing of soil samples to determine the number of sclerotia makes it possible to estimate the degree of infection of a given field with the prediction of the possibility of growing a commercial crop. Cropping the land with a lesser or nonsusceptible host plant until few sclerotia are present permits resumption of beet culture with a fair chance of avoiding serious infection.

Improving the sugarcane industry in Louisiana.—Recent additions to improved varieties of sugarcane previously introduced by the Louisiana Station, cooperating with the Department of Agriculture, with

great benefit to the sugarcane industry of Louisiana, promise to further improve sugar production. These include C. P. 28-11, C. P. 28-19, and C. P. 29-320, which are disease resistant, high in sucrose content, and good yielders in stubble crops. The yellow type of mosaic occurs to a very limited extent in C. P. 28-11 and C. P. 28-19, while the green type occurs in C. P. 29-320. As yet, no field of these canes in the State shows a percentage of mosaic high enough to be of any economic importance. With C. P. 29-320 it may be possible to begin sugar-house operation not later than the first week in October, thus reducing the cold hazard and prolonging the grinding season about 20 percent. The advantage of windrowing before severe freezes to reduce deterioration from cold in storage has been confirmed. Variety C. P. 28-11 has shown great cold resistance.

The decided advantage of early planting, about November 1, has been demonstrated by the Louisiana Station. Although the station showed the advantage of judicious use of fertilizers, it has found that maximum profitable yields cannot be obtained through the application of commercial fertilizers alone. The single-eye method of summer planting developed by the station has made it possible to produce as many as 1,300 stools of cane from a single stool within a year and to place a variety under general commercial cultivation 5 or 6 years earlier than by ordinary methods of planting. A refractometer method of rapid determination of maturity of cane in the field and the proper point at which the cane should be topped also developed at this station furnishes the cane grower with a simple, rapid, and practical method for determining what fields are mature enough to harvest. The station's recommendation that freshly cut cane be delivered to the mills is now generally accepted throughout the State and has been responsible for large savings.

Sugarcane varieties for sirup making in Puerto Rico.—As a result of rather extensive breeding experiments, field trials, and sugar-house tests, the Puerto Rico Station has designated four varieties of sugarcane, namely, F. C. 916, P. R. 803, Mayaguez 28, and B. H. 10(12), as especially suited to sirup making. A blend of two or all four of these varieties for the manufacture of commercial sirup is recommended as better than any one alone. The station has found that addition of a small amount of acid or partial fermentation of the juice improves the color of the sirup.

Sugarcane growing in the Everglades.—The Florida Station reports that experience of the 1934-35 winter has shown that soil and climatic conditions are so favorable for the sugar industry in the Everglades that even after that area had experienced freezing weather earlier than at any time in the past 40 years, with very low minimum temperatures, a successful harvest season extending 75 days after freezing was possible. A rapid and accurate field method of sampling large areas of sugarcane for determination of deterioration after freezing has been devised by the station.

Stubble deterioration of sugarcane.—Fields suffering from deterioration of stubble cane, long a serious problem of the Louisiana sugar industry, as the Louisiana Station points out, are characterized by poor stands and slow growth. The factors responsible for stubble deterioration include low temperature, lack of aeration resulting from poor drainage, poor condition of the cane at harvest time,

too early cutting in the fall, injury (too severe pruning) to old roots or lack of vigor of the roots, and red rot disease caused by *Colletotrichum falcatum*. The method of determining the resistance of varieties to stubble deterioration worked out by the station makes it possible to determine the resistance of a new variety before release to growers.

Control of white grubs in sugarcane by the giant toad.—Sugarcane fields in Puerto Rico have been practically cleared of the white grubs, larvae of the June bug, formerly a serious pest of sugarcane, by the giant toad (*Bufo marinus*), introduced by the Puerto Rico Station in 1920 from Barbados. The toads also have greatly reduced other pests in the island.

SORGHUMS

Atlas sorgo.—Atlas sorgo, a variety developed by the Kansas Station, cooperating with the Department of Agriculture, was found to have a wide adaptation, being grown by many farmers in Midwestern States, in Texas, and in Oklahoma, Missouri, Kentucky, and Tennessee. Atlas has been widely grown and is popular in eastern Kansas and is a successful feed crop in central Kansas. Its high resistance to chinch bugs has been an important factor in its success in eastern Kansas. Nebraska Station tests show the merits of Atlas as a silage and feed crop in that State and that in dry years it produces more tons per acre than the best variety of corn.

The Oklahoma Station, cooperating with the Department of Agriculture, has found Atlas to be much more immune as regards chinch bug infestation, egg production, survival, and injury than Dwarf yellow milo, which is very susceptible.

Disease-resistant milo.—Selections of milo resistant to the so-called milo disease, which is especially severe to the common varieties of milo and milo derivatives in several of the Southwestern States, have been made by the Kansas Station. The work has so far progressed that resistant selections of Beaver and Wheatland (both milo \times kafir) and Day milo, appear to be assured.

SOYBEANS

Soybeans in Idaho.—Within the past decade soybeans have become a crop of major importance in the United States, most of the soybean acreage being grown in the Corn Belt and adjacent States. Recent investigations by the Idaho Station have shown that the crop also can be satisfactorily grown in the warmer sections of Idaho, especially in sections where corn can be cured properly. Their successful production in Idaho depends upon the choice of adapted varieties. Idaho-grown seed was found to be superior to that imported from States in the Middle West. Row plantings in hills or drills rather than broadcast seeding and also inoculation appeared essential for success with the crop, which can be grown with the same cultural practices required for corn or navy beans.

Use of soybean oil in paints.—Among the important and varied uses of soybeans is as a source of oil for paints. Tests by the Illinois Station have demonstrated its value for this purpose for both exterior and interior use. Exposure and other tests convince the sta-

tion that soybean oil has a permanent place in paint manufacture. The results on interior panels support findings of others that 30 percent and more of the oil used in paint can be made up of soybean oil when properly treated and when suitable driers are used. Many Illinois farmers are painting their homes and barns with soybean-oil paints with very satisfactory results.

Harvesting soybeans for hay.—Soybean hay, the Ohio Station finds, ordinarily should be cut by September 1 in northern Ohio and by September 10 in southern Ohio. When cut early in the season in good curing weather, soybeans may be cured most economically if left in the swath until well wilted and then placed with the side-delivery rake in small windrows to be turned once or twice. Late in the season, soybean hay usually must be cocked for a satisfactory product, but it should first be cured in swath and windrowed as much as the weather permits.

Combinations of soybeans and corn for silage.—From its extended studies the New York (Cornell) Station concluded that any good silage corn and a suitable variety of soybeans, grown together in the same row and spaced at the rate of one corn to three soybean plants in each 9 inches of row yield more digestible nutrients than does the same corn grown alone at the optimum planting rate, and likewise, the nutritive ratio is narrowed materially as a result of the high protein content of the soybeans.

All factors considered, a combination of corn and soybeans for silage is a practice to be highly recommended to the dairymen of New York State as a means of increasing production, improving silage, reducing the amount of concentrates necessary, and adding another legume to the cropping system, all of which tend to decrease the cost per unit of production.

ALFALFA

Alfalfa in Ohio.—The conditions under which alfalfa can be most successfully and profitably grown in Ohio are dealt with exhaustively in a recent bulletin of the Ohio Station, based on results of many years of research by the station, showing the extent to which successful culture of alfalfa depends on proper coordination of soil treatment, varieties grown, seeding methods, cutting practice, and management of the stand. The area in alfalfa in Ohio reported to have been 274,000 acres, or 2.75 percent of the crop land of the State in 1933, which the station believed might profitably be increased, rose in 1934 to 342,000 and in 1935 to 438,000 acres.

Diseases of alfalfa.—A damping-off disease of alfalfa seedlings, which occurs on fallowed land and may become an important factor in the establishment of new fields of alfalfa, has been shown by the Kansas Station to be due to a species of the fungus *Pythium*. The injury is most severe on soils that are slightly acid in reaction.

In the Wisconsin Station's comparison on wilt-infested soil, Cossack alfalfa, while severely diseased, was intermediate in survival between other susceptible and the wilt-resistant sorts, but only the resistant Ladak and Turkistan maintained good stands at the end of 5 years. Wilt infection reduced winter survival of such normally hardy and susceptible alfalfas as Grimm, Canadian Variegated, and Cossack so that they appeared superficially like nonhardy sorts after infection.

The Utah Station observes that certain varieties of alfalfa, especially Ladak, present a possibility of combining resistance to both wilt and stem blight in the same plant or strain.

Winter hardiness in alfalfa.—From a search for factors indicative of winter hardiness in alfalfa the Michigan Station concludes that heredity is the most plausible explanation of winter hardiness. Currently, field tests aided by electrical conductivity tests are deemed necessary for determining the relative winter hardiness of different lots of alfalfa.

Effect of cutting on organic food reserves in alfalfa roots.—Early and frequent cutting of alfalfa, as in the bud stage, the Kansas Station found in cooperation with the Department of Agriculture, resulted in a lower carbohydrate and nitrogen content in the roots when winter came, and the converse held with infrequent cuttings. At least 8 to 10 inches of growth after the last regular cutting seemed necessary for maximum storage of organic reserves in the roots before winter. Removal of aftermath when growth ceased in the fall resulted in a lower carbohydrate and nitrogen content than was obtained by leaving aftermath on the crop which also resulted in a more vigorous growth and increased yield of the first cutting the next spring.

Burning mulch on alfalfa.—The Iowa Station finds that burning natural mulch material March 15 and April 1 apparently does not injure the alfalfa, whereas burning April 15 and May 1 retards the new growth markedly. Burning straw mulch at any time appears to be distinctly injurious.

Curing alfalfa hay.—Raking alfalfa hay soon or within a few hours of cutting and curing in windrows is the most practical curing system tested by the Michigan Station. Hay cured in cocks has been satisfactory in quality, usually having a slight advantage in protein content, but this curing method requires extra labor to build the cocks and materially longer to dry the hay down enough for storage. The station finds that the curing of alfalfa in the swath is unsatisfactory, swath-cured alfalfa always being lowest in protein content.

The Indiana Station has secured evidence that enzymes are directly responsible for the destruction of vitamin A in alfalfa during curing and that sunshine only has an indirect effect by producing temperatures which accelerate enzyme activity.

Spontaneous combustion of alfalfa hay.—From an experimental study of spontaneous combustion of alfalfa hay, the Michigan Station concludes that in the case studied—

large masses of hay containing a certain amount of moisture favor the spontaneous generation of heat. Probably, also, the large mass retains the heat developed which may on this account reach the danger point. The density of the mass which is increased by chopping may also restrict the circulation of air within the mass, thus favoring the retention of heat. Ventilation flues with slatted walls to favor air movement through the mass appear to be a practical means of dissipating heat which is generated even in the normal curing of hay. * * * Care should be taken in storing chopped hay to keep the moisture content to a reasonable limit, at least as low as that allowable in making a good quality of bright hay. When stored in large volume, ventilation of the mass also appears advisable.

Composition of alfalfa as affected by soil type and treatment.—Studying the effects of lime, superphosphate, and potash on the composition of

alfalfa grown on nine of the principal soil types of the State, the Michigan Station found that in general the phosphorus content of both stems and leaves of alfalfa grown on soils not requiring lime was increased by superphosphate applied alone or with potash. In some cases, very marked differences occurred in the phosphorus and calcium contents of alfalfa grown on the different soils. Alfalfa produced on the heavy soil types contained more nitrogen and less phosphorus than on the light soil types. Limestone, superphosphate, and potash did not appreciably affect the ratio of stems to leaves.

Influence of soil reaction (pH) on yield and feeding value of alfalfa hay.—Yields and the nitrogen percentage in alfalfa and mixed hay grown by the New Jersey Station on soils ranging in acidity from pH 4.6 to 7, usually were increased as the pH of the soil was increased. In some cases yields were four to five times as large and the percentage of nitrogen in the hay from well-limed soil often was nearly double compared with that on strongly acid plats. Usually yields and the nitrogen percentage in the hay were higher with magnesian limestone than with calcium limestone.

Pasturing alfalfa in Michigan.—Grazing trials by the Michigan Station as well as farm experience indicate the superiority of alfalfa pasture over sweetclover or permanent grass pastures, predominantly Kentucky or Canada bluegrass, for many Michigan conditions. The advantage of alfalfa was most marked in dry, hot weather. Avoidance of heavy grazing in September, a critical month for alfalfa in Michigan, appears important. However, the grazing range for this crop extends from early May until winter with pastured stands normally lasting 3 to 5 years, but occasionally as long as 10 years. Precaution should be taken to avoid bloating of sheep and cattle pasturing on alfalfa.

CLOVER AND SWEETCLOVER

Adapted red clover for New Jersey.—The superiority of adapted red clover to alsike for New Jersey, the inferiority of foreign seed compared to native strains, the merits of adapted American clover, especially from Ohio and nearby States, and of Tennessee anthracnose-resistant seed, and the value of buying certified seed of superior strains have been demonstrated by the New Jersey Station.

Fertilizer experiments with sweetclover.—Good yields of sweetclover were obtained by the New Hampshire Station on old hay and pasture soils where the lime and fertilizer requirements were satisfied. The resulting stands of sweetclover established in old pastures by different tillage methods after using lime and superphosphate were almost in direct proportion to care in seedbed preparation. Seed from Ohio, Michigan, Alabama, and Canada all proved winter hardy, but northern-grown seed matured earlier.

Limited use of limestone on sweetclover.—For years farmers thought that about 2 tons of limestone per acre must be broadcast in order to grow sweetclover successfully on acid soil in Kansas. This involved considerable expense per acre. Tests by the Kansas Station on farms in eastern Kansas during the last 2 years show that from 300 to 500 pounds of ground limestone per acre drilled with sweetclover seed at planting by using a combination grain and fertilizer

drill with grass-seeder attachment, will greatly increase the yield on many soil types deficient in lime. Farmers having grain drills without a fertilizer attachment have reported success from sowing the mixture of the lime and seed through a grain drill.

Sweetclover and red clover as green manures.—Comparing medium red clover, Hubam sweetclover, and white sweetclover in a 2-year rotation of corn and oats alternating since 1926, the Iowa Station finds that corn yields were increased 17 percent by white sweetclover, 12 percent by Hubam sweetclover, and 8 percent by medium red clover. Oat yields for the period 1927–33 were increased 18, 9, and 5 percent, respectively, by these legumes.

LESPEDEZA

The growing of lespedeza has spread rapidly in the United States, especially in the South. The production of lespedeza for hay alone has arisen from 357,000 tons for the 1928–32 average to 947,000 tons in 1934, and 1,214,000 tons estimated in 1935. A similar situation exists in regard to the harvested acreage. Coincidentally, the crop has received much attention from the experiment stations in the North and South.

Lespedeza in Illinois.—From results of experiments since 1922 on different soil types throughout the State, the Illinois Station finds that lespedeza's value as a hay and pasture crop, relative acid tolerance, drought resistance, relative freedom from insect and disease pests, and low seeding cost, place it definitely in Illinois agriculture. The crop is best adapted to the southern half of the State. It is resistant to drought and heat but is sensitive to freezing weather in early spring and late fall and yields best where there is at least a moderate moisture supply. Its special value lies in ability to grow and produce a good stand where alfalfa, red clover, and sweetclover will not thrive. Lespedeza does best, however, on productive, well-drained, nonacid soils. Korean appeared in general to be the most desirable annual variety, although in northern Illinois Harbin is the only commercial sort expected to produce enough seed for self-seeding. The perennial *Lespedeza sericea* showed promise as a hay crop in most of southern Illinois. Although lespedeza is used most widely for pasture, either alone or in mixtures, it makes a good quality of hay that compares favorably with alfalfa in chemical composition, palatability, or in meat and milk production. Where well adapted, it serves as green manure and protects against soil erosion.

Lespedeza sericea in Tennessee.—The Tennessee Station has considered the merits of both annual and perennial lespedeza for many years. For the perennial *L. sericea*, the station advises the sowing of 15 pounds per acre of scarified seed from February to late July, although best results came from March or early summer plantings by avoiding or harrowing out weeds, or 25 pounds of unscarified seed in January or February, and planting on a firm seedbed and covering slightly or not at all in freezing weather. Seeding with a nurse crop has given good results, while seedings on established meadows or pastures have failed. The hay yield decreased as the number of cuttings increased from two to four per season, but it surpassed that of annual lespedezas. The hay resembles annual lespedeza in

chemical composition, although less palatable to some animals and apparently inferior to alfalfa in quality.

OTHER LEGUMES

Vetch and related crops.—The Austrian winter pea, monantha vetch, smooth vetch, and hairy vetch, according to results of the Georgia Coastal Plain Station gained in cooperation with the Department of Agriculture, are the winter legume cover crops best adapted to south-Georgia conditions. For best yields, seeding should be made in October, preferably drilling at the rates specified, and the seed covered from 2 to 4 inches. Mixing these legumes with oats gives variety for grazing and makes hay cutting and curing easier, although no advantage in yield is apparent. The winter legume cover crops have increased the yields of both corn and cotton and should be turned under at least 15 days before the latter crops are planted.

In extensive tests in many localities, seeking to supply needs for forage crops in areas unsuited to alfalfa culture, the California Station has found that while no one variety is adapted to all conditions, the common, purple, and hairy vetches, and Austrian winter peas meet the requirements in most sections of California. It has made recommendations for practices in growing these crops.

The value of hairy winter vetch as a green-manure crop in standing corn has been established by the New Jersey Station, which secured a stand of the vetch by broadcasting the seed in corn in late August without cultivation.

Seed production with legumes in Hawaii.—Seed yields made by a number of green manure and forage legumes, including pigeonpea, blue lupine, crotalaris, velvetbeans, etc., grown at different spacings by the Hawaii Station indicate very favorable possibilities for seed production for most kinds of legumes tested. Fairly close spacings usually gave better results than wide spacing.

Improved strains of peanuts.—By rigid selection the Georgia Station has secured strains of peanuts which are characterized by high yield, disease resistance, and desirable character of seed. The Macspan peanut, selected by the Texas Station from Little Spanish, has surpassed other varieties on the Gulf coast prairie of Texas.

Field peas.—Approximately 750,000 bushels of field peas are produced annually in Colorado, the Colorado Station states, over 90 percent being from the San Luis Valley. The crop is well adapted to the mountain valleys. The station has determined and published the best methods of growing and using the crop. Cut when the pods are well formed, the field pea makes nutritious hay, and its mixture with oats or barley provides good hay and silage, which also furnishes a better balanced ration. It may be pastured with sheep and hogs with good results, especially if supplemented with other feeds. The peas make a good green manure for late-planted crops.

That considerable mechanical loss occurs in harvesting, threshing, cleaning, and drilling seed peas was determined by the Idaho Station. The station found that graphite applied as a thin uniform coating to seed peas minimized drill injury and did not affect germination.

Control of the Mexican bean beetle.—In its research on the relation of cultural practices to bean beetle control and the use of insecticides on string, lima, and Horticultural beans, the Connecticut (State) Station found that yield reduction due to attacks of the Mexican bean beetle were largest on beans planted July 1 and 10 and least on beans planted June 1 and 10. Sprays were most effective and less spray material was required when the plants were spaced 4 inches or wider apart. Magnesium-arsenate sprays and dusts, barium-fluosilicate sprays and dusts, copper-lime-calcium arsenate dusts, and derris and pyrethrum dusts controlled bean beetles satisfactorily and produced substantial increases in yield. Furthermore, derris and pyrethrum dusts left no undesirable residues on the pods. Accumulation of poisonous residues on pods depended on their size when dusted or sprayed rather than on the amount of rainfall between treatment and harvest. Any poisonous material applied after the pods formed left an undesirable residue.

The Michigan Station observes that when Mexican bean beetle attacks begin early enough in the season to show before pod formation, the insect may be controlled with a spray composed of 2 pounds of magnesium arsenate in 100 gallons of water, applied to both surfaces of the leaves. The station has also found that certain derris and pyrethrum sprays and dusts are effective means of controlling the beetle without danger of harmful residue.

FORAGE CROPS, COMBINATIONS, AND MIXTURES

The marked shift from cereals and cultivated crops to meadows, pastures, and other forage, in response to national and State programs for crop adjustments, and land use and conservation, and demands for forage caused by drought and other adverse factors, have been responsible for increased station activities in this field.

Emergency forage crops.—Comparative tests of numerous emergency forage crops by the Minnesota Station indicate that Amber sorgo and other sorghums can be used profitably in time of drought. Sudan grass and soybeans also proved their ability to endure drought and when well managed furnish good yields of pasture or dry forage even in times of moisture shortage.

Cereals as emergency hay crops.—Clover, timothy, alfalfa, and mixtures of various kinds usually meet the needs for hay under normal conditions, but when these crops are short, emergency hay crops must be found. Under such circumstances, the Ohio Station points out, oats, wheat, barley, and rye have certain advantages for hay purposes. Their adaptation to soil and climate is known; the regular rotation need not be disturbed; they are available for feeding early in the season; and they may be adapted to almost any class of livestock by harvesting at the proper stage. Cereals sown for grain crops may be diverted to this use. In general, the cereal hays compare favorably with mixed clover and timothy hay in average composition.

Crop mixture trials in Michigan.—Oats and barley, the Michigan Station finds, constitute the most desirable mixture in yield and total digestible nutrients per acre, no other combination tested equaling these crops alone or in mixture. Field peas in mixtures reduced total yields, increased threshing difficulties, and produced too few

peas to improve protein content. Best seedings of sweetclover were obtained in field peas and in the early-maturing, stiff-strawed Spartan barley and Loggold oats.

Choosing legumes and perennial grasses.—The legumes considered of greatest value for different uses or soil conditions in Iowa, the Iowa Station concludes from extensive experiments, include alfalfa, medium red clover, mammoth red clover, alsike clover, white clover, biennial white and yellow sweetclovers, Hubam clover, Korean lespedeza, dalea, and soybeans. The grasses of greatest economic importance in the State, considering seed supply, usefulness, and soil adaptation, are Kentucky bluegrass, timothy, redtop, brome grass, reed canary, and orchard grass. The station has published much information on their varieties, soil and cultural needs, and uses for hay, pasture, and green manure.

Fertilizing meadows.—Old meadow on Merrimac fine sandy loam was improved, the Massachusetts Station finds, in quality and yield by top dressing with fertilizer mixtures high in nitrogen and potash, whereas little or no benefit was derived from superphosphate. Nitrogen, phosphoric acid, and potash in a ratio of about 3:1:2 is advised for old meadows on soils of this type. The station finds that on similar soils the quality of mixed grass meadows will so deteriorate in 6 or 8 years, in spite of rational fertilization, that reseeding is desirable.

Fertilizing timothy hay.—Both yield and quality of timothy hay can be improved, according to the Ohio Station, by top dressing with nitrogen fertilizers. Maximum effects on yield have been obtained from applications made March 15 to April 15, and at the rate of 62 pounds of nitrogen per acre. The most economical rate has been 46 pounds of nitrogen per acre. The yield response decreases and protein content increases as the application is delayed from April 15 to June 15.

Artificial curing of forage crops.—Throughout the Gulf States there are large areas which produce heavy crops of hay but have been only partly developed because of unfavorable climatic and other conditions for the natural curing of hay. The Louisiana Station has found that artificial drying provides a more uniform product, of better color and higher protein, and with less loss of leaves than occurs in field curing. The station also found that the artificially cured hay contains more vitamin A and vitamin E than similar hays cured in the sun. Artificial curing, however, reduced somewhat the vitamin D content as compared with sun-cured hay. Artificially cured soybean hay, with which most of the experiments were made, was considerably higher in feeding value than field-cured hay and was more palatable.

Relation of rainfall to calcium and phosphorus in hay.—The Oklahoma Station has found that the calcium and phosphorus contents of bluestem, little bluestem, and alfalfa vary with the amount of effective seasonal rainfall. During periods of high rainfall the calcium content of the plants decreased and phosphorus rose, and the reverse occurred when effective rainfall was low. It is thought that this furnishes a useful means of judging whether the hays of a given season are supplied adequately with these mineral constituents.

PASTURES

Permanent pastures.—Noting a decided trend in American agriculture toward a greater appreciation of grassland, particularly permanent pastures, the Maryland Station undertook a State-wide study of permanent pastures on 275 Maryland farms. It found that Kentucky bluegrass and white clover, with lesser amounts of crabgrass, orchard grass, timothy, redtop, Canada bluegrass, and black medic or yellow trefoil constituted the principal vegetation of the permanent pastures and that for the State as a whole, more than 1 acre in every 4 is entirely unproductive from the grazing viewpoint because of weeds. In general, the pastures need both lime and phosphorus for improvement. For the most part, application of 500 to 1,000 pounds of lime to the acre every 3 to 5 years was indicated as sufficient. An application of superphosphate every third year at the rate of 200 to 500 pounds per acre would provide enough phosphorus in most cases. Pastures often are rendered less productive by improper cultural practices and poor grazing management, particularly overgrazing and grazing when the soil is very wet. Manure is of special value on poor hillsides, gravelly knolls, and areas of very thin or shallow soil where it is hard to obtain a stand of grass. Proper placement of shade and drinking places is indicated as a means of conserving fertility contained in the droppings.

Place of pasture in farming.—Pasture, the Iowa Station finds, serves two major purposes in Iowa farming. It supplies roughage important to livestock production and it reduces erosion and helps maintain soil fertility. In a study of the utilization of pasture and its relationship to other parts of the farm business on 30 to 50 farms in each of 16 areas in Iowa, the station observed that the carrying capacity of permanent pasture varies widely in different soil and topography areas. On an average for all areas, 1.7 acres of permanent pasture or 1.3 acres of rotation pasture are required per animal unit. The farms with the highest proportion of land in pasture tended toward the raising of beef cattle, whereas those with the lowest proportion in pasture produced more hogs or sold grains. Permanent bluegrass is the most important type of pasture in the State, comprising 80 percent of the total. Sweetclover or a mixture of red clover and timothy are generally used for rotation pasture.

An all-year pasture system.—Good pasture the year round, the Missouri Station reports, is now within the reach of every Missouri farmer. The pasture system developed by the station in cooperation with the Department of Agriculture consists of bluegrass pasture in late spring, early summer, and winter, Korean lespedeza in mid-summer and late summer, and barley or other grain pasture through the whole fall and early spring. This sequence gives its best results on the more productive soil types and elsewhere on land of average to good fertility, while on areas of medium to low fertility the combination of redtop, lespedeza, and rye will generally be found more practicable than any other for the all-year pasture plan.

Fertilizing pastures.—Several of the experiment stations, especially those of Connecticut (Storrs), Florida, Kentucky, Louisiana, Ohio, and West Virginia, working in cooperation with the Department of Agriculture, have shown that the carrying capacity of pastures can

be substantially and profitably increased by proper use of fertilizers. Pastures which have been top dressed are ready for grazing sooner than unfertilized pastures and new plants in fertilized pastures develop more rapidly. Any surplus production on pastures can be made into hay. A cheaper method of fertilizing, but with slower returns, is the application of phosphates alone which tends to "bring in" the clovers. The clovers in turn add nitrogen to the soil. This method of fertilizing has been found worth while on some of the more valuable pasture lands in the Virginias. It is usually considered uneconomical to buy fertilizers for pastures on the poorest soils.

When grown for pasture on upland Norfolk sandy loam, low in fertility, by the Alabama Station, the Dallis, carpet, centipede, and Bermuda grasses responded directly to nitrogen and the clovers to phosphorus, and Dallis grass and hop clover showed marked responses to lime. Lime in combination with fertilizer treatments, except with nitrogen alone, materially reduced the cost per ton of increased yields. Pasture plants became established more quickly on limed and fertilized areas, and there were fewer weeds than on untreated land.

Applications of lime, phosphorus, and potassium, the Arkansas Station finds, are even more important than nitrogen in developing improved productive pastures. In the dry season of 1934, pasture production expressed as increased weight of grazing stock was 91 percent greater on a pasture receiving minerals only than on one receiving only nitrogen. Stimulation of growth of legumes by the minerals early in the season increased the production while forage from the early legumes—hop clover, bur clover, and white clover—lasted, and effects of this increased growth presumably supplied more nitrogen for the Bermuda grass from June until the season closed than was applied directly to the other pasture. The greater production from the pasture receiving minerals continued to the end of the season.

Outside of the Connecticut Valley, the New Hampshire Station reports, increases from mineral fertilizers other than nitrogen upon grass have been slight. Over most of the State pasture response depends on whether white clover is present or will grow with proper fertilization. If white clover cannot be induced to grow by complete fertilizers, straight nitrogen carriers are indicated for subsequent use on the pasture. From 2 to 11 times as much feed as the same money would buy commercially has been produced in these trials with fertilizers.

Discovery by the Oregon Station, working in cooperation with the Department of Agriculture, that the use of sulphur as a fertilizer would increase the average yield of alfalfa and other legumes about 1 ton per acre has been of great benefit to both crop producers and livestock feeders of the State.

The estimated 4,500,000 acres of pasture in Pennsylvania are mainly on the Volusia, Westmoreland, and DeKalb soil series, the DeKalb being most extensive and least productive. In pasture experiments on DeKalb silt loam soil, the Pennsylvania Station, cooperating with the Department of Agriculture, found that phosphoric acid applied at the rate of 64 pounds per acre every 2 years produced a return, as measured by milk produced, of about \$11 per acre above

fertilizer costs. The addition of 50 pounds of potash per acre to pasture receiving phosphoric acid increased the net return above fertilizer costs about \$1 per acre, whereas application of 24 or 48 pounds of nitrogen annually to pasture receiving phosphoric acid and potash did not appreciably increase the net returns per acre.

Pasture and range plants.—Dallis grass, carpet grass, hop clover, and lespedeza, the Alabama Station finds, have proved to be the most promising pasture plants for sandy upland soils and Dallis grass has predominated in the drier years. Black medic and bur, white, Ladin, and Carolina clovers have proved susceptible to cold, being killed at 8° F., while hop clover successfully withstands this and other low temperatures. Hop clover has grown better in combination with Dallis grass than with carpet or Bermuda grass and lespedeza better in combination with Bermuda grass.

The characteristics which make crested wheatgrass most desirable for dry-land pasture in Colorado are endurance to low temperatures and to drought, comparative ease of establishment, high palatability, and vigorous seed production. From trials under varied conditions in the State, the Colorado Station suggests for stands shallow (1 inch or less) early spring planting (Mar. 15–Apr. 1 in northern Colorado) on a clean firm seedbed, preferably after a clean cultivated crop, using a mixture of crested wheatgrass 7 pounds, smooth brome grass 8 pounds, and yellow sweetclover 2 pounds per acre.

Napier or elephant grass, introduced into Hawaii in 1915, and important as a pasture and green-fodder crop, is reported by the Hawaii Station as aggressive, heavy yielding, high in nutritive value, and persistent in growth over a period of years. The grass, while drought-resistant, responds to abundant moisture and can be grown successfully under irrigation. Yields of from 50 to 90 tons of green fodder per acre per year under favorable growing conditions, and a carrying capacity of one mature beef animal per acre per year for Napier grass pastures under proper management, are reported. Analyses show that Napier grass resembles Sudan grass in protein and crude-fiber content when cut at the proper stage for green fodder, but has a considerably higher percentage of total ash.

Legumes, the Kentucky Station has observed in its experiments, improve pastures by directly and indirectly increasing the total dry matter production, by improving the vigor of grass sods and preventing weed growth, and by increasing the protein and mineral content of pasture herbage.

Orchard grass, the New Jersey Station found, has ranked high in palatability and has been outstanding in yield in extensive comparisons of pasture grasses.

Balbo rye has been found by the Tennessee Station to surpass other ryes tested for pasture and grain production in middle Tennessee. It furnished an average of 169 pasture days for 1 steer per acre versus 107 from ordinary commercial rye, gains made by steers being in proportion, and it averaged 21.5 bushels per acre compared with 16 for Abruzzi rye.

Pasture management and improvement.—Practices suggested for improving permanent pastures, by the New Jersey Station, include the removal of trees and shrubs, mowing, systematic grazing, spreading droppings, and fertilizing, especially with nitrogen, for intensive

grazing. The station provides for meeting the midsummer feed shortage with temporary pastures as Sudan grass alone or with soybeans, sweetclover, stubble or seedling pastures, and second-growth alfalfa and clover.

Depleted permanent grass pastures suffering from erosion, the Ohio Station finds, can be improved most economically by applications of limestone and superphosphate when conditions favor white clover, i. e., moisture-retentive soils, rains in late summer and fall, and reasonably heavy spring grazing. Otherwise nitrogen fertilizers also are needed and the cost is greater.

In areas of Kentucky bluegrass pasture, severely affected by drought, the Iowa Station showed that injury from drought and heat was aggravated greatly by overgrazing, indirectly causing the death of about 90 percent of the grass. Reseeding with legumes, and in some cases also with grasses, and better soil treatments are advised as means of improving conditions, but resting the pasture is of primary importance.

Reseeding of cultivated dry lands, the Montana Station finds, can be done successfully on a large scale and the lands returned to their original value as grazing areas, especially by sowing crested wheatgrass. This grass was shown to surpass native grass in carrying capacity for cattle and to have a high feeding value. Reseeding also provides a useful means of controlling soil blowing and restoring organic matter to the soil.

The possibility of reseeded run-down ranges, a matter of growing concern to ranchmen, has been given considerable attention by stations in the Western States. The New Mexico Station has been successful in reseeded with certain forage plants which appear especially suited to the natural conditions with little or no soil preparation or cultivation besides harrowing. It has succeeded best as a rule with chamiza (*Atriplex canescens*) and winter fat (*Eurotia lanata*), merely scattering the seed on the soil surface, although both plants thrive much better on plowed than on unplowed land.

HENRY M. STEECE.

HORTICULTURAL CROPS

Outstanding in horticultural work of the stations during the year were studies leading to the production of higher quality and more profitable products free from disease and insect injuries and excessive spray residues.

FRUITS AND NUTS

Improvement of varieties by breeding.—The development of varieties of fruit adapted to specific regions or to specific uses, such as canning, freezing storage, and drying, is more important today than ever before because of the ever changing and more exacting requirements. Many of the stations located in the apple regions continued their search for color mutations, the Michigan Station being unusually active and successful in this direction.

Among other fruits originated by the New York State Station to receive particular recognition during the year were the Kendall apple and the Gorham pear.

A new blight-resistant pear developed at the Pennsylvania Station was named Richard Peters in honor of a founder and early president of the Philadelphia Society for Promoting Agriculture.

The Ruby grapefruit, a pink-fleshed variety found in a commercial orchard in the lower Rio Grande Valley, was announced by the Texas Station as a very promising addition to subtropical horticulture.

The two unusually severe winters just past proved very destructive to fruits in general but served to emphasize differences in winter hardiness; for example, the Michigan Station reported that the Oriole peach bred by the New Jersey Station withstood -17° F. to the extent of yielding about half a crop of fruit.

Nearly 20,000 trees of seven new peach varieties originated by the New Jersey Station were distributed in the State in 1934.

A valuable new dark-red sweet cherry named Gil Peck in honor of the late Gilbert Peck, extension pomologist of Cornell University, was dedicated by the station in an appropriate ceremony attended by native Indians from the State reservations where Professor Peck had rendered great service in upbuilding Indian agriculture.

The Taylor red raspberry introduced by the New York State Station is a cross between the English variety Lloyd George and Newman. This new raspberry, characterized by large size, long conic shape, firm flesh, and high quality, promises to be an important addition to American fruit culture. Sodus was obtained by crossing the Dundee with Newburgh.

Considerable progress in the development of apricots and raspberries resistant to drought and low temperature was made by the North Dakota Station, located in a region of intensely severe winters.

Improved practices in fruit culture.—That soil moisture may be a critical factor in nonirrigated apple orchards in regions of limited precipitation is indicated by the discovery by the Nebraska Station that practically all the available moisture had been exhausted to a depth of about 35 feet in a 17-year-old apple orchard with 86 trees per acre. The practical deductions were, (1) orchards should not be planted on old orchard sites or following alfalfa, (2) trees should be widely spaced, and (3) trees should be planted on the contour to reduce the run-off of precipitation.

From long-continued experiments with mature trees, the Massachusetts Station concluded that young, vigorous-bearing apple trees are much less influenced in their fruiting behavior by pruning than is commonly believed and that favorable soil, culture, fertilizer, spraying, and fruit thinning are of greater importance in improving size and quality of fruit than is pruning. It is suggested, however, that pruning is beneficial as a means of removing weak and declining wood and water sprouts.

Comparable observations were made by the New York (Cornell) Station, which reported that the effects of pruning on yield, color, size, and freedom from injury of apples were not found outstandingly important in their experiments. Pruning is conceded useful in admitting light to the lower limbs and in the production of a strong, well-balanced apple tree with proper limb distribution.

Nitrogen was shown to be the most important fertilizing element for apples and pears in experiments conducted by the Washington Station. It was suggested that nitrogen may be supplied effectively

either as leguminous cover crops, leguminous hay, manure, or fertilizer. No evidence was secured that phosphorus or potash without nitrogen was of any benefit.

Despite considerable evidence from widely distributed sources that nitrogen is the principal limiting nutrient in apple orchards, certain indications pointed to necessary modifications in this point of view; for example, the Massachusetts Station discovered that potash is deficient in many apple orchards in the State and that in the presence of inadequate potash large nitrogen applications may be harmful rather than beneficial to growth and yield. The burning of the margins of the leaves, a characteristic symptom of potash injury in many plants, was observed in some, but not all, of the potash-deficient trees. However, low potash content characterized potash-deficient groups.

Applications of superphosphate in connection with nitrate of soda were noted by the New Hampshire Station to increase the production of Baldwin apple trees beyond that of nitrate of soda alone but not, however, to a profitable extent.

Irrigated citrus trees were found by the Arizona Station to obtain approximately two-thirds of their moisture from the upper 2 feet of soil. The use of water was closely correlated with mean monthly temperature to the extent that water must be applied four times as frequently in summer as in winter. Eliminating the losses due to evaporation, percolation, run-off, etc., Washington Navel orange trees and grapefruit trees used, respectively, about 2.5 and 3.5 acre-feet of water annually.

In citrus rootstock experiments at the California Citrus Experiment Station, in which records were taken on about 6,500 trees, it was determined that the sweet orange is the most desirable understock for standard varieties of lemons, oranges, and grapefruit. It was noted that many lemon groves in which the trees were budded on sour orange roots were declining after a period of from 18 to 25 years in the orchard.

Nitrogen fertilizers increased tree vigor and set and yield of peach fruits but delayed their maturity in experiments reported by the Georgia Station, leading to the recommendation of the use of a mixed material containing nitrogen, phosphorus, and potash.

Faced with the fact that the low viability of seeds of many early-ripening varieties of stone fruits limits greatly progress in the breeding of improved early-maturing kinds, considerable progress was made by the New York State Station and the New Jersey Station in the development of methods by which immature embryos of early-ripening peach varieties could be germinated on sterile media and following afterripening at low temperature be later transferred to the open soil.

Leaf-bud propagation of the black raspberry, recently developed by the Iowa Station, was suggested by the station as a practical means of rapid propagation of valuable new varieties and for reproducing certain purple-cane raspberries which propagate with difficulty by the usual means.

The mulching of upland blueberries with salt-marsh hay was reported by the New Jersey Station as an effective measure in increasing growth, and a new type of blueberry cultivator provided with 7-inch disks on either side so arranged as to approach the base

of the plants without injury to the lower branches was designed by the station.

A guide to varieties and culture of blueberries was published by the Massachusetts Station, with special reference to the improvement of wild blueberry lands.

As pointed out by the Arizona Station in a recent bulletin, the essential requirements for date culture are a long, hot growing period, moderate winter temperatures, little rainfall, and low relative humidity.

As a result of work with fertilizers for pecans, the Florida Station advises that adequate plant food be applied to pecan soils if growth and yield are to be maintained and suggests that a mixture be used in which the ammonia is derived partly from inorganic and partly from organic sources, the exact formula to vary with the type of soil and the amounts and kinds of cover crops grown. The fertilizer treatments did not apparently affect the composition of the nuts to any material extent. Hairy vetch and *Crotalaria spectabilis* proved to be effective winter and summer cover crops, respectively.

The poor filling of pecan nuts was found by the Arizona Station to be associated with too great vegetative development of the tree in summer and autumn and some evidence was found that the difficulty might be overcome in part by limiting irrigation and nitrates and also by root pruning pecan trees with a plow.

Tung oil production.—A paper on the present and probable future status of tung oil production in the United States was issued by the Texas Station and indicated at the present time a sufficient acreage to supply, when full bearing, about one-half the present oil requirements of the Nation.

Protection against fruit insects.—Chemically treated bands fastened around the trunks of apple trees which had been previously scraped of all rough, dead bark tissue were reported as decidedly helpful in the control of codling moth by several of the stations. At the Virginia Station bands applied after all the old bark was removed were said to have trapped from 50 to 70 percent of the descending worms.

Bands were particularly valuable, the New York State Station found, in orchards where codling moth infestations were so severe that the routine spraying operations failed to provide adequate control. Chemically treated bands were found to kill nearly 100 percent of the worms that spun cocoons beneath the bands and were particularly important in reducing the first-brood worms, the reduction of which was vital throughout the season.

Chemically treated bands were observed to be less effective during the seasons 1934 and 1935 than during previous seasons at the Kansas Station. The decreased efficiency was apparently associated with the extremely high temperatures experienced. High temperatures shortened the life cycle of the codling moths and reduced the period of exposure to the chemicals, volatilized a high percentage of the beta naphthol in the bands and changed the physical state of the chemicals from a gummy, sticky consistency to a dry crystalline condition. These changes were considered responsible for the reduced effectiveness.

Search for effective spraying materials that would leave no hazardous residues was continued aggressively by many stations. After

investigating various proposed substitutes for lead arsenate the Virginia Station concluded that apple growers must continue to use this material for the control of codling moth, washing their fruit in acid baths to remove objectionable residues. Certain suggestions were made for the improvement of the washing operation, including the daily renewal of the acid wash, the use of more fresh water in rinsing, and the addition of lime to the rinse water at regular intervals. A mixture of goulac, a byproduct from the digestion of wood pulp, with calcium bisulphide was found, when combined with equal parts by weight of hydrated lime, to be an effective emulsifier for all kinds of oil and oil combinations. Wax tailings, a heavy viscous byproduct of the candle industry, was, when combined with tar oil, successfully employed by the Virginia Station as a dormant spray for scales and aphids on the apple tree.

Calcium arsenate was reported by the Washington Station to give encouraging results as a substitute for lead arsenate in the control of codling moth, and when certain sulphates, such as iron and copper, in combination with hydrated lime were added to the calcium arsenate spray foliage injury was almost completely prevented.

Fluorine sprays in combination with flotation sulphur when used as the prepink and pink applications gave outstanding control in Ohio apple orchards of the apple flea weevil which had been observed by the station to be increasing in abundance wherever clean culture was not practiced.

Woolly aphis control in Oregon was materially furthered by the introduction by the Oregon Station in 1928 of a parasite, which is now distributed in practically all Oregon apple orchards. Since the aphis is associated with the spread of perennial canker it is confidently expected that the parasite will have an indirect function in reducing canker infection in the State.

Tar-distillate oil sprays were shown by the New York State Station to be useful in the control of rosy apple aphid, black cherry aphid, and certain other insects, and directions were prepared by the station for the use of these sprays.

The paradichlorobenzene treatment widely used for the control of the common peach borer was demonstrated by the Oregon Station to be very effective in the control of the western peach and prune root borer. Kills as high as 90 percent or more were secured in experiments, and prune orchardists reported kills of from 65 to 100 percent.

The burning over of waste areas adjacent to orchards and the trapping of insects by jarring of the trees were found by the Delaware Station to be effective measures for reducing the population of plum curculio in peach orchards where the numbers of insects were so large as to preclude successful control by spraying.

Parasites were found by the New York State Station to be important factors in the control of the oriental fruit moth. Since the colonization of the parasite, *Macrocentrus ancylivorus*, oriental fruit moth populations were said to have steadily decreased to the point of very light infestations. Favorable results were also reported by the Ohio Station from the same parasite in controlling oriental fruit moth in that State.

Based on the subzero temperatures in the winter of 1933-34, the lack of food for the third brood during the preceding summer, and

the unusual activity of parasites in 1934, the New York State Station was able to make valuable predictions as to the probable prevalence of the oriental fruit moth in 1935. Studies of the parasitism of the codling moth in New York State by *Ascogaster carpocapsae* indicated that arsenical sprays kill many of the adult parasites. Dead and dying trees in New York fruit orchards following the severe winter of 1933-34 brought about a large increase in shot hole borers, leading to the recommendation that such trees be immediately removed (p. 57).

Successful control of the root knot nematode (*Heterodera maroni*), one of the principal limiting factors to the production of many deciduous fruits on the sandy soils of California, was accomplished by the California Station with the cooperation of the Department of Agriculture by the development of resistant understocks. Certain varieties of Asiatic peaches, notably Bokhara, Shalil, and Yunnan, yielded highly resistant seedlings, and certain varieties of apricots and vegetatively propagated strains of myrobalan plum also proved resistant. With these stocks almonds, apricots, peaches, and plums may now be grown on soil upon which their culture was practically prohibited by nematodes.

The discovery by the California Station that dormant oil sprays could be effectively prepared by the orchardists by adding spray oil and spreader separately to the tank and maintaining a uniform mixture by agitation was reported to have cut down the cost of materials approximately one-half and improved the coverage and oil-depositing properties. Over 5,000,000 gallons of sprays prepared in this manner were said to have been used in six northern California counties without any recorded injury and with satisfactory results.

The great increase in production of avocados has been accompanied, according to the California Station, by a corresponding increase in the losses resulting from insects, and, therefore, information on avocado insects and their control was accumulated and disseminated by the California Station.

Airplanes were found by the New Jersey Station to be materially helpful in distributing dusts for the control of leafhoppers on cranberries and blueberries, and a dust made up of 1-percent rotenone with some pyrethrum applied at the rate of 50 pounds per acre gave very good control.

Apple scab, a very serious fungus trouble to many pear and apple varieties, was found by the New York State Station to be somewhat better controlled by spraying with sulphur or copper materials during bloom in addition to the usual program. Despite the toxicity of such materials to pollen no serious results followed, provided one or two favorable pollination days occurred prior to the spraying.

Control of fruit diseases.—To the long list of host plants of fire blight, recognized for many decades as one of the chief hazards to pear growing in the United States, the California Station added 34 species of the rose family. The disease in its severest form appeared, however, to be limited to a relatively few plants closely allied to the apple and pear. Improved control of fire blight was reported by both the California and Tennessee Stations from spraying fruit trees in full bloom with a weak bordeaux mixture.

In its work on the development of fire blight-resistant pear stocks the Oregon Station reported that out of some 7,000 French pear

seedlings included in inoculation trials, 7 had proved vigorous and highly resistant to blight and that seedlings of these 7 were being grown in an effort to build up seedling stocks of high resistance.

Zinc sulphate sprays were found by the Florida Station to be effective in restoring to a thrifty condition citrus trees affected with an obscure but severe disease known as frenching.

A scaly bark disease of citrus trees known as psorosis was reported by the California Station to be transmitted during budding in the nursery. This fact plus mosaiclike symptoms on the leaves indicated that psorosis is a virus trouble.

Brown rot injury to peaches in transit was reduced substantially by the Virginia Station by the use of a sulphur spray applied just before harvest, supplemented by dusting the fruit with sulphur during packing.

Zinc in various forms was used with notable success by the California Station in correcting the physiological disease of peaches known as little leaf, which had caused widespread losses, especially to orchards located on sandy soil. Three methods of treatment were employed successfully under different conditions, (1) zinc sulphate applied to the soil, (2) zinc sulphate used as a spray, and (3) pure zinc glazier points driven into the wood.

Control of pecan rosette through application of zinc sulphate continued to be a successful practice for the growers, as reported by the Arizona Station.

As a practical means of reducing potential injury to black walnuts from European canker the West Virginia Station recommended that plantings be established in sunny locations and that the trees be spaced to admit the greatest possible amount of sunlight.

Spray residues.—The development of effective methods of removing toxic residues from sprayed and dusted fruits is recognized as one of the most noteworthy recent achievements of research in the stations and Federal Department of Agriculture. Constant developments of new spray materials and spraying practices necessitate changes in methods of residue removal.

An effective codling moth control program correlated with successful removal of the resulting residues was developed at the Oregon Station.

Plans for an effective and moderate-priced home-made flotation washer were distributed by the Pennsylvania Station among fruit growers.

Prevention of injury by cold.—As an aftermath of the severe winter of 1933-34, which was reported to have killed more than 1,000,000 of the 6,000,000 apple trees located in New York State alone, critical studies by several of the stations in the affected region showed that other factors besides variety were involved in the losses (see p. 56).

In a commercial Baldwin orchard in the western portion of the State, the New York State Station observed that trees receiving nitrate nitrogen and lime not only made the greater growth and yielded more fruit but also showed less winter injury than trees not so treated.

Apple trees which fruited heavily in the preceding summer were found by the Vermont Station to have suffered more severely than trees which fruited lightly, suggesting that winter tolerance, al-

though largely a varietal matter, depends somewhat on cultural care and condition of the trees.

Evidence of injury to the internal tissues of such highly cold-resistant varieties of apple as McIntosh was observed by the Maine Station.

A rather unique observation on winter injury was forthcoming from the New York State Station to the effect that apples such as Baldwin with triploid chromosomes were as a group more severely damaged during the severe winter than were diploid apples such as McIntosh. The wood of the triploids was found, on the average, to be coarser in cell structure.

Large applications of nitrogenous fertilizers were observed by the Georgia Station to reduce winter injury to the trunks of peach trees but to have little apparent effect on the resistance of the flower buds.

In the Hudson River Valley sweet and sour cherries on mazzard roots suffered more root injury from the winter cold than did the same varieties on mahaleb roots. However, since mazzard-rooted trees over a long period of years proved more resistant to summer drought and other troubles, the station concludes that despite occasional severe winter injury the mazzard is the better rootstock for cherries in the valley.

Factors influencing quality of fruits.—From measurements and observations on buds and other external characters, the New Jersey Station established standards by which the growth status of Delicious apple trees could be determined in summer.

Cull apples, a source of material losses to growers, were found by the Missouri Station to be due to several causes, among which small size was most important. Poor color and mechanical injuries were also factors of major significance.

With the organization of 90-percent clean-apple clubs, several of the New England States made marked progress in producing better grades of apples.

Increasing yields per acre were reported by the Washington Station to be the most effective method of reducing costs of producing pears and apples. The average cost per box of picked pears was 2.5 times greater in poor-producing than in the high-producing orchards.

Different degrees of fruit thinning of peaches was found by the Ohio Station to reduce total yields, with early thinning in mid-June, especially in the presence of heavy crops, increasing the proportion of large-sized fruits.

Cracking of cherry fruits was observed by the Idaho Station to vary markedly with varieties, the large-fruited kinds being more susceptible than the smaller. In ascending order of resistance were Bing, Tartarian, Napoleon, Lambert, Republican, Oregon, Waterhouse, and Eagle. From a physiological standpoint varieties having a small amount of skin per unit of soluble solids were the most susceptible to cracking.

The girdling of Sultanina (Thompson Seedless) grapevines was found by the California Station to increase the size of berries by 50 to nearly 100 percent. With varieties with seeds girdling was much less beneficial, the maximum gain being less than 20 percent.

Preservation of fruit.—The precooling of apples before packing was found highly desirable by the Illinois Station, since fruit placed in

the package while still very warm was liable to overripening and decay even under the best refrigerator-car conditions. Oiled paper wraps also reduced materially the rate of cooling.

In working with Jonathan and Grimes Golden apples the Iowa Station found that firm, well-colored fruit stored at temperatures of 31°, 36°, and 50° F. kept well in storage. At 31° and 36° the apple developed only a trace of soggy break-down and no mealy break-down by March 1. Considerable evidence was secured that different varieties of apples have an optimum storage temperature considering both the maintenance of quality and the freedom from various storage troubles.

In storage experiments in controlled chambers the New Hampshire Station found evidence that the same variety of apple from different orchards may vary significantly in keeping quality as reflected in firmness, acidity, and flavor.

Chemically treated paper wraps were found beneficial by the Oregon Station for preventing losses to apples and pears in storage from scald and other troubles, and a new type of wrapper containing oil and a fungicide was developed.

That preservation of fruit by quick freezing offers a potentially valuable means of handling surplus crops was suggested by the New York State Station as the result of experiments conducted cooperatively with a commercial firm. Freezing storage was found applicable to apples, peaches, plums, raspberries, dewberries, blackberries, cranberries, and strawberries, as well as cider and other fruit juices. Frozen fruits were found useful in the manufacture of ice cream, pastries, preserves, sauces, and jellies.

Investigations by the California Station, the Federal Government, and other agencies upon the precooling of deciduous fruit for shipment to eastern markets having shown the desirability of this operation, the California Station continued studies of better methods of precooling and of handling the refrigerator cars. The station published results of studies of the use of portable fans for facilitating the rapid and uniform cooling of fruit in refrigerator cars and on various other features.

Fruit products and byproducts.—Recognizing the importance of increasing profitable outlets for fruits, several of the stations are now carrying on definite research programs to determine better methods of handling and utilizing fruit products.

Apple pectin was observed by the Delaware Station to develop during the ripening period and not to be present in immature fruits.

Studies of pectin by the Maryland Station showed this substance to be an important factor in cold resistance and in the growth and ripening processes of the fruit.

An apple concentrate perfected by the Washington Station was said to be useful as a substitute for fresh fruit in the preparation of various food products, and a silage of excellent quality was produced by the station from apples run through a silage cutter from which the blades had been removed. Milk production was maintained at a high level when apple silage constituted a large portion of the cow's rations, and a combined cull-apple and alfalfa silage not only had a high protein content but was also extremely effective in milk production.

The browning of preserved orange juices was found by the California Station to be the result of oxidation and to be preventable by small additions of sulphites or other antioxidants to pasteurized or benzoated juices.

The use of citrus fruits for the preparation of pectin was investigated by the Florida Station and found practicable.

A comprehensive study by the New York State Station of the causes of deterioration of bottled cider and grape juice indicated that the small amount of air remaining at the top of the bottle may cause undesirable changes in juices. In the case of Concord grape juice, oxidation resulting from the presence of this air caused a muddy, bluish color and a loss of flavor. Methods of pasteurization were developed that resulted in better flavored fruit juices. Carbonation was accomplished by putting a small piece of dry ice, solid carbon dioxide, in each bottle.

Muscadine grapes were found by the Georgia Station to yield a very attractive light-colored juice, the tannin content of which was related to the length of time the juice remained in contact with the residual pulp, seeds, and skins.

VEGETABLE GROWING

The development of new and improved varieties.—Difficulties in maintaining stocks of vegetables in their original condition due to natural crossing in the field, the need of resistant forms to offset the attacks of various insects and diseases, and the need of new varieties to meet special requirements were reflected in great activity in vegetable breeding at several of the stations.

A wealth of valuable new tomatoes, Rutgers from the New Jersey Station, Indiana Baltimore from the Indiana Station, Penn State from the Pennsylvania Station, Marhio from the Ohio Station, Glovel from the Florida Station, Farthest North from the North Dakota Station, and Nystate from the New York State Station, were the results of breeding studies with this important vegetable at the stations mentioned. Each variety possesses qualities that make it peculiarly adaptable to the section in which it was bred.

A sweet corn bred by the Puerto Rico Station was said to be the only true sweet corn available on the island and to be highly promising as a winter crop for shipment to the continental United States.

Suwannee sweet corn from the Florida Station was held promising as a superior variety for that State.

As a result of trials of all obtainable varieties of sweet corn, the New York State Station issued a finely illustrated monograph, the third in a series dealing with vegetables grown in New York.

By following a plan of rigid selection, the Wisconsin Station, in cooperation with the United States Department of Agriculture, succeeded in developing a new strain of cabbage possessing complete resistance to *Fusarium* disease and also having good market qualities. This cabbage was designated Wisconsin Ballhead to distinguish it from susceptible types of the Danish Ballhead variety.

A yellows-resistant cabbage of the Copenhagen type was reported as practically ready for distribution by the Ohio Station.

Definite progress in improving the collard, a vegetable of great importance in southern gardens during the winter period, was reported by the Louisiana Station.

Considerable progress in the breeding of new onions was made by the California Station. A new strain of California Early Red known as Early Red U. C. No. 1 was said to be replacing practically all of the older strains of this variety, and an improved strain of Australian Brown was also released. Efforts in cooperation with the Department of Agriculture to develop thrips-resistant onions were reported as meeting with success.

Two new mosaic-resistant strains of Stringless Refugee type beans, created by the Idaho Station cooperating with the Wisconsin Station, were named Idaho Refugee and Wisconsin Refugee in recognition of the States participating in their development.

A new beet with a solid red interior was introduced by the Ohio Station under the name of Ohio Canner.

The Old Dominion spinach developed by the Virginia Truck Station was reported by the Ohio Station as valuable for the fall, winter, and early spring crops. This spinach has proved partially resistant to a mosaic which frequently destroys fall crops of other varieties.

A valuable strain of tipburn-resistant Grand Rapids lettuce was introduced to the trade by the Ohio Station.

Wilt-resistant watermelons for California were promised as a result of breeding studies at the California Station.

Improvement of cultural practices.—As a result of extensive experiments with beans, tomatoes, cabbage, beets, and sweet corn, the New York State Station reported that careful placement of fertilizers in bands adjacent to the plants greatly increased the efficiency of a given amount of material, prevented injury to the germinating seed or young transplants, and favored more uniform maturity of the crop. Analyses of the fertilizer recovered at measured time intervals after placement showed a rapid diffusion of the soluble salts into the soil solution, so that within a few days the hazard of injury to the roots or seed was greatly reduced.

From experiences at the New Jersey Station, the application of fertilizers in irrigation water was suggested to growers as a means of securing economy of labor, saving of material, and insuring timely application.

As a result of long-continued studies of a large number of different fertilizers accompanying a rotation including red clover, the Illinois Station found that sweet corn responds definitely to rather small modifications in the fertilizer formula. Of 63 different treatments the one which included 400 pounds per acre of a 0-16-12 material supplemented by 50 pounds of sodium nitrate as a later side dressing gave the best results on the dark prairie loam utilized in the study.

Ammonium sulphate increased the yields of onions at the New Mexico Station, whereas the use of acid phosphate alone was definitely detrimental.

Continuing studies in seed production, the New Mexico Station found that seed of several biennial vegetables, including cabbage, can be produced in that State by fall sowing.

That the color of table beets may be enhanced by regulating the time of planting so that beets mature in September or early October was shown by the New York State Station in field experiments.

Yields of from 8 to 10 tons of artichoke tubers secured by the New Jersey Station on strong, sandy soils and higher yields on loams in good tilth indicated that this plant has possibilities both for food and as a potential source of sugar on certain New Jersey soils.

Late cutting of asparagus was found by the Iowa Station to be detrimental to the profitable life of the planting. June 15 appeared to be the most satisfactory concluding date from the viewpoint of profitable returns. With regard to spacing, either 2 or 3 feet in the row and 5 feet between rows proved satisfactory with respect to the size of spears and the total yield.

The early harvesting of pickling cucumbers was found by the Michigan Station to increase the total number of fruits produced, but the total weight was decreased. Despite the higher prices received for the smaller pickles the financial returns per acre were largest when 4-day intervals elapsed between pickings. High financial returns were apparently determined by large yields, which in turn depended upon proper soil, culture, and the control of pests.

The problem of securing a practical substitute for the constantly decreasing supply of horse manure in the culture of mushrooms was solved partially by the Pennsylvania Station by the development of a compost of wheat straw, brewers' grain, and urea. When mixed with equal parts of horse manure this compost gave as large yields of mushrooms as did horse manure alone and at a considerably lower cost.

A method of establishing the fertilizer needs of vegetables by determining the nutrients present in the conducting tissues was developed by the Kentucky Station. The presence of abundant nitrogen as compared with phosphate caused a heavy utilization of phosphorus, with a decrease of phosphate in the tissues. On the other hand, when nitrogen was deficient phosphate tended to accumulate.

Wide interest in the so-called minor plant foods was manifested at various stations. Following careful determination of the copper, iron, manganese, and iodine in vegetables and fruits procured on the open market, the Massachusetts Station undertook with success to increase the amounts of these elements in lettuce, spinach, onions, beets, and carrots by special treatment of soils. Buckwheat and spinach grown on soil deficient in available magnesium developed symptoms varying from mild chlorosis to actual killing of the leaf tissues. Some evidence was secured by the Iowa Station that iron and boron are essential to the normal growth of the tomato, and the New Jersey Station found that small amounts of boron and manganese are necessary for the normal development of radishes, tomatoes, corn, peas, and nasturtiums.

Corn, oats, peanuts, Cayana cane, Simpson cane, Napier grass, pearl millet, *Crotalaria* spp., and Whippoorwill cowpeas responded favorably at the Florida Station to applications of zinc sulphate. Definite symptoms of malnutrition in cowpeas and velvetbeans were found correlated with zinc deficiency.

Environmental conditions prevailing in the potential hop-growing sections of New York State were observed by the New York State Station to compare very closely in temperature and rainfall with those of the best European hop-producing areas. The station suggested that alluvial and river-bottom soils in a large part of central

and western New York are potentially favorable for the successful culture of the hop vine.

Control of insect pests and diseases of vegetables.—Studies by the New Jersey Station upon derris and cube root showed that samples containing similar amounts of rotenone and total extractives were equally toxic to aphids. Derris used as a dust was considerably slower in killing than that applied either as a water suspension or extract.

Derris dust was found by the New York State Station to have particular promise as a means for combating cauliflower worms, two applications at the rate of 25 to 30 pounds per acre giving good control. The nontoxic nature of derris to humans was a decided advantage, because no harmful residues were left on the marketable product.

Activated nicotine dust made of 10 pounds of nicotine sulphate, 10 of pulverized fresh stone lime, 5 of dry lime-sulphur, and 80 pounds of hydrated lime was reported by the New Mexico Station to be highly effective in the control of various garden insects.

That both alcoholic and kerosene extracts of pyrethrum may be used in combination with bordeaux mixture without deterioration of the pyrethrum during the first 2 hours, provided Penetrol is used as the adhesive agent, was suggested by the New Jersey Station. With rosin fish-oil soap as the adhesive the pyrethrum began to break down almost immediately.

Considerable work on basic copper chloride, basic copper sulphate, copper aluminum silicate, cuprous oxide, and copper phosphate as possible substitutes for bordeaux mixture was done by the Ohio Station. When bentonite was added as the adhesive agent, these copper compounds proved valuable for use with arsenicals for spraying various cucurbits, increasing the yields of both pickles and muskmelons.

Dusting celery with a sulphur and lime mixture was found by the New York (Cornell) Station to give excellent protection against the tarnished plant bug, the major pest of muck-land celery. Information was distributed to the growers on the probable occurrence of serious outbreaks and the best methods and time for applying dusts. Green varieties of celery were apparently immune to the tarnished plant bug injury.

The control of stinkbugs was found possible at the Virginia Station by the simple expedient of planting vegetables and fruits some distance from natural hosts, such as black locust, honeylocust, dogwood, linden, redbud, elder, and boxelder.

The serious virus disease of tomatoes known as streak or die-back was found by the California Station to be caused by the spotted wilt virus transmitted by thrips. It was observed that infected cauliflower, cabbage, celery, and ornamentals carried the virus over the winter and that many different species of plants were attacked by the disease.

Off-type tomato plants, presumably chance crosses between the Globe and Red Currant varieties, were observed at the Ohio Station to possess resistance to leaf mold and were used by the station in the development of commercially desirable resistant varieties.

Many crosses between commercial tomatoes and the resistant red cherry type were made by the Massachusetts Station. Among the

seedlings there were a few producing fruit of fairly good quality, and further efforts were made to increase the size of fruits.

Disease-free tomato plants were produced at the Georgia Station by treating tomato seed with a 1-to-3,000 solution of corrosive sublimate for 5 minutes, particularly when the seed treatment was supplemented with bordeaux mixture applied in 2-week intervals to the seedlings.

As a means of reducing losses to greenhouse tomato growers caused by certain virus diseases, particularly mosaic, mottle, and streak, the Washington Station recommended certain protective measures, such as the avoidance of mechanical contact between diseased and healthy plants, the removal of diseased plants, the avoidance of handling tobacco or potatoes when working with the tomatoes, the destruction of possible weed carriers, the control of insects by fumigation, etc.

In investigations of the relation of bacteriophages to the control of Stewart's disease (bacterial wilt of corn) the Ohio Station showed that when virulent strains of the bacteria were treated with the phage they were much reduced in virulence or were no longer able to parasitize corn plants. When naturally infected corn seeds were soaked in a phage filtrate very little disease developed. The bacteriophage was found consistently in association with the corn wilt organism in plants which for a time had exhibited symptoms of the disease and later recovered. The phage was also found in the soil of continuous corn planting where the amount of disease had been decreasing from year to year. The station believes that the bacteriophage may be considered a factor in the control of Stewart's disease.

Some progress was recorded by the Illinois Station in the control of Stewart's disease of sweet corn, sometimes sufficiently severe to cause complete failure of the crop, and always a distinct menace. Resistant varieties, such as Golden Cross Bantam, Top Cross Bantam, Top Cross Whipple, Whipple Yellow, and Top Cross Spanish Gold offered a measure of control.

The careful selection of seed and the use of good cultural methods was found by the New York State Station to be important measures in reducing losses to kidney beans from root rots, which in 1934 were the primary cause of the failure of kidney beans in the State. Attempts were made to isolate strains resistant to root diseases.

An extremely sensitive test for manganese was developed by the New Jersey Station for use in connection with chlorosis of spinach due to a deficiency of available manganese in the soil. It is believed that this test will enable growers to determine whether observed chlorosis is or is not due to manganese deficiency. The dusting of spinach seed with red copper oxide, Vasco 4, or zinc oxide was found practical and effective in preventing losses from damping-off which caused severe injury to early fall plantings.

Application of 10 pounds of borax per acre was found by the Florida Station to be effective in preventing a celery trouble known as cracked stem, which had caused severe losses to growers. Thirty pounds of borax per acre was definitely toxic to the plants.

The pasteurization of greenhouse soils with electric heat was found by the New York State Station to give satisfactory control of damping-off, and a special type pasteurizer was designed which would heat the soil to 45° to 50° C. and hold it there for 12 hours or more without additional heat.

Treating seed with red copper oxide and the soil with zinc oxide was found by the New York State Station to give almost perfect control of damping-off. Zinc oxide had some value as a seed treatment but was not as effective generally as was the red copper oxide.

Factors affecting quality in vegetables.—Potatoes were found by the Georgia Station to contain very small amounts of iodine and not to vary in iodine content when grown on different soil types. Leafy vegetables, on the other hand, showed a fair content of iodine, and the iodine seemed to vary with the water available to the growing crop, leading to the conclusion that water alone may account for great variations in the amount of iodine present in crops grown under otherwise comparable conditions. It is stated, however, that water is only one of several factors which may influence iodine content.

That the quantity of iodine in vegetables, particularly corn, may be influenced by applications of fertilizer containing iodine salts was indicated in studies reported by the Kentucky Station.

Grading of vegetables.—Except in the presence of oversupplied markets, rigid grading on the farm of vegetables was not found by the Rhode Island Station to be desirable from the viewpoint of financial returns. Under ordinary conditions there was only a limited market which would pay the premium necessary for highly graded vegetables.

Markets for fruits and vegetables.—An economic study of Worcester and Boston produce markets and market areas, to the point of furnishing a basic quantitative description of the sources of supply and marketing channels for local fruits and vegetables, was made by the Massachusetts Station. Preliminary plans for a new regional produce market were made. Since the close of the study these plans have been completed by the Massachusetts Extension Service and the State Department of Markets, working in cooperation with a new farmer's cooperative which has been formed for the purpose of constructing a regional market. This study, which was made possible with emergency funds, has been of value in making new markets possible.

ORNAMENTAL HORTICULTURE

No phase of experimental horticulture has shown such great changes and advancements in recent years as that dealing with the culture of ornamental plants in the greenhouse and in the open ground.

New varieties of flowers.—Substantial progress was made by the California Station in the development of snapdragons resistant to the rust disease, which has hitherto practically eliminated this beautiful flower from gardens. As a result of the work a pure white variety was released by the station.

Two resistant strains of snapdragon, a yellow and a white, possessing not only resistance but true-breeding color characteristics as shown through three generations, were developed at the Massachusetts Station.

Improved cultural practices.—From several years' studies upon the growing of carnations in sand supplied with constant-drip nutrient solutions, the New Jersey Station concluded that this method is both

practical and economical. Sand culture gave better control of growth because the sand could be flushed more effectively than soil, and the nutrients supplied were of highly available form. Although total production was slightly less in the sand lots, the flowers were equal in quality and length of stem, and in the Enchantress carnation there were fewer split blossoms in sand than in soil. Rust and spider mites were less noticeable on the sand-grown plants. A very material advantage for sand was the fact that it could be used for more than 1 year with good results. Good progress was also made in the production of greenhouse roses in sand.

In experiments to determine how long summer-budded roses may be held to advantage in cold storage before forcing in the greenhouse the Illinois Station observed increasingly severe losses when planting was deferred beyond the usual planting time in January or February. Paraffining the tops had little or no effect in preventing losses to late-planted stocks.

In testing methods of influencing the color of forcing hydrangeas the Ohio Station reported success in changing pink color to blue by applying aluminum sulphate either as a solution in water or as dry salt to potted plants. Medium-pink varieties responded more favorably than did dark-pink varieties, and of the many tested Goliath and Blue Prince gave particularly favorable results.

Investigations at the Ohio Station showed that many species of plants respond to supplemental light, and intensities as low as that produced by 15- to 40-watt Mazda lamps were frequently effective. As a result of the studies, the Ohio Station classed plants in three groups with respect to light responses as follows: (1) Those, such as roses and carnations, which failed to respond greatly to light changes, (2) those, such as *Matthiola*, pansy, and Shasta daisy, which gave earlier or increased blooming, and (3) those, such as chrysanthemum, which were delayed in flowering by additional light. Certain varieties of chrysanthemums flowered much earlier when the normal day was cut to 10 hours.

The blooming period of chrysanthemums was hastened by the New Jersey Station as much as 1 month by reducing the daily exposure to sunlight.

Orchid culture, long under investigation at the New York (Cornell) Station, was found possible without the presence of natural fungi, hitherto believed necessary to growth. The addition of sugar to the cultural medium was beneficial in promoting strong growth.

Control of insect pests and diseases of ornamentals.—Barium fluosilicate dust was developed by the Massachusetts Station, working in cooperation with rose growers and with the aid of E. R. A. funds, as a means of controlling the adult form of the Fuller's rose beetle, a serious pest in greenhouse rose culture. Some progress was made in the controlling of grubs in the soil, and so successful were the measures that not only control but also extermination of the pest in greenhouses is believed possible.

Sulphur fungicides, widely used in the Northern States for the control of rose diseases, were found by the Florida Station to cause severe burning of foliage during the summer season and were considered unsafe for use in the State.

Valuable information was disseminated by the New Jersey Station on the nature and control of various diseases and insects attacking azaleas and rhododendrons.

Chlorosis of hydrangeas was cured by the Ohio Station in 3 weeks by applying ferrous sulphate to the soil. Other materials, including ferric sulphate, zinc sulphate, and manganese sulphate, were also beneficial, but to a lesser extent.

The cyanide, naphthalene, and corrosive sublimate treatments of gladiolus bulbs during storage or at planting time were all found by the New York State Station to be promising methods for controlling thrips.

Aliphatic thiocyanate sprays were found at the Ohio Station to give excellent control of the Mexican mealy bug on chrysanthemums, and many commercial growers were said to have adopted this new method of control.

The trouble of the sweet pea known as the fasciation disease was found by the Ohio Station to be associated with a hitherto undescribed bacterial organism. The symptoms resembled those of crown gall, and the disease caused a decrease in vigor much as occurs in the case of crown gall. Soil and seed disinfection were found to control the disease, which also occurs on garden peas, petunias, and chrysanthemums.

Information on the life history and control of various insect pests of the boxwood, including the leaf miner, oyster-shell scale, boxwood mite, and boxwood psylla, was reported by the New Jersey Station.

Noteworthy progress in the selection and propagation of red cedar trees possessing virtual immunity to the common and widespread cedar apple rust has been achieved by the West Virginia Station. Under comparable conditions of exposure the resistant strains develop no galls, or only a few small galls, while the susceptibles form large galls, sometimes resulting in the actual death of the branches.

The knowledge that at least one species of bark beetle is concerned in the dissemination of the dreaded Dutch elm disease led to a study by the Michigan Station of various insects attacking elms. It was observed that bark beetles (*Scolytus* spp.) are attracted to diseased or weak trees, and various methods of protecting such trees were proposed.

J. W. WELLINGTON.

FORESTRY

Improved cultural practices in forestry.—The annual burning of grass on rolling longleaf pine lands was found by the Mississippi Station, working cooperatively with the United States Department of Agriculture, to double the growth of grass and to increase the organic matter and nitrogen in the upper 6 inches of soil.

In studying the relation of site to the growth of pine the Arkansas Station found that superior sites are those which give a height growth of 90 to 110 feet in 50 years. Such sites are characterized by soils that are immature, flat, and of high silt or silty sand content with permeable subsoil and adequate water supply. Poor sites were those with a high degree of slope and consequent heavy run-off and with the soil extremely stony, gravelly, or sandy, usually with a rather stiff sandy clay subsoil within 12 to 16 inches of the surface.

The value of thinning white pine and Scotch pine plantations was demonstrated by the Vermont Station in carefully controlled experiments. In the case of 20-year-old white pines planted 4 by 6 feet, the removal of 45 percent of the basal area resulted in a marked increase in the available sunlight and amount of precipitation reaching the soil, and increased the rate of growth of the trees of largest diameter and best form during the 4 subsequent years.

From observations on experimental plantings of black locust in different parts of the State, the Alabama Station concludes that locust is not well adapted for planting in gullies, on eroded hillsides, or on old fields unless it is possible to first prepare the soil and to provide some cultivation and fertilizer. Such procedure is conceded too costly, except possibly in the production of fence posts.

From long experiences in the western part of the State, the Kansas Station points out that there is only a limited number of species of trees and shrubs that may be grown successfully in the semiarid sections of western Kansas and suggests that careful preparation of the soil is necessary in the production of vigorous trees. Windbreaks and shelterbelts cannot be planted successfully in sod or in newly turned sod and on exposed sites. It is recommended that newly planted trees be watered during periods of drought.

Bamboo improvement.—New species of bamboo introduced in recent years by the Puerto Rico Station with the cooperation of the Department of Agriculture are said to be of great promise for use in farm building and furniture construction. With the aid of E. R. A. funds, studies were made of various methods of utilizing bamboos, and much progress was made in the propagation and dissemination of desirable varieties. The station believes that the bamboos may become a very important factor in improving the standard of living in rural districts on the island.

Wood preservation.—White pine posts treated with preservatives by the open-tank method and also under pressure were found by the New Hampshire Station to be sound at the end of 5 years as compared with 75 percent of decay in untreated posts. Brushing the posts with preservatives was followed by 11 percent of decay during the same period. Zinc arsenate proved to be an effective preservative.

J. W. WELLINGTON.

ANIMAL PRODUCTION AND PRODUCTS

The problems relating to the production of animals and their products have been attacked by the experiment stations on the basis of their economic importance. In a more fundamental manner, some of these problems have been studied to get at the basic causes or principles influencing them.

ANIMAL NUTRITION

The field of animal nutrition has received the attention of investigators for many years. New and important discoveries are being made that give a clearer understanding for improvement in methods of feeding and management of livestock.

Effect of saline and alkaline waters on domestic animals.—Analyses made by the Oklahoma Station show that many waters from springs,

deep wells, and other sources in that and adjacent States are heavily saturated with sodium, calcium, and magnesium chlorides, calcium, magnesium, and sodium sulphates, minor quantities of carbonates, bicarbonates, and other ions in smaller amounts, and that such waters are injurious to animals compelled to drink them. Sodium chloride is somewhat less active than calcium chloride, and magnesium chloride is the most injurious, the injury coming evidently in the limited amount of water the animal will consume. The alkali solutions are more injurious than saline waters, the injury being more direct as a chronic enteritis is apparent. Animals can become accustomed to drinking waters not possible to consume at first. Egg and milk production, however, decrease during the adjustment period, and there is a limit beyond which no further adjustment is possible.

Mineral deficiency in range plants.—Many range grasses and browse plants have been shown by the New Mexico Station to be deficient in calcium and phosphorus. In areas where these deficiencies occurred, the mortality of calves is high and growth of animals retarded. The areas where the deficiencies occurred were mapped to assist livestock men in the feeding of mineral supplements.

Effect of retarded growth on ultimate body size.—In experiments with rats the New York (Cornell) Station found that when the animals were retarded in growth and not allowed to attain maturity until after 766 and 911 days they could not attain a body size equal to that of animals grown to maturity younger, but that even after these long periods of suppressed growth the male rat retained a growth potential greater than the female, although the males of the retarded group grew no larger than the normal females of this species. In both groups both sexes attained extreme ages beyond those of either sex that grew normally.

Chemical control of growth.—The California Station has found that a concentration of a chemical substance of animal tissues, known as glutathione, is related to rate of growth and body size.

Toxicity of cod-liver oil.—A synthetic diet containing cod-liver oil has been found by the New York (Cornell) Station to produce muscle and heart injuries in rabbits, guinea pigs, sheep, and goats. Sheep and goats on pasture receiving a daily dose of 0.7 gram of cod-liver oil per kilogram (2.2 pounds) of body weight died within 93 days, showing toxic symptoms. Animals receiving half this amount succumbed within 226 days, but an intake of 0.1 g did not produce any observable harm during this period. Amounts of cod-liver oil found injurious were not in excess of amounts sometimes recommended for various farm animals and for children. This suggests that the feeding of oil to the farm animals and to children in any but the lowest amounts is open to question. The harmful factor in the oil appears to lie primarily in the part of the oil which does not contain the vitamins, and hence is largely eliminated in the manufacture of cod-liver oil concentrates which are frequently used as sources of vitamins in place of the oil itself.

Nutritive value of corn.—Yellow corn normally contains more carotene (vitamin A) than white corn. The New Jersey Station has found that the difference in color is not positively indicative of the usual differences in nutritive value. A yellow-corn ration excelled a white-corn ration in palatability and gain in body weight, but the white-corn ration excelled in digestibility of food energy. The same sta-

tion found that from the standpoint of vitamin A (carotene) content, yellow-corn silage could not be considered superior to that made from white corn.

Vitamin content of hays.—The artificial drying of alfalfa hay may be done without the loss of vitamin A potency or without the loss of other nutrients as compared with field-cured hay, the New Jersey Station finds. On the other hand, stored alfalfa loses vitamin A potency, particularly during the warmer months, so that at the end of 3 months of storage 50 percent of the vitamin potency disappears. From a study of lake vegetation as a possible source of forage, the Minnesota Station suggests that forage of high protein content may be obtained from shallow lakes.

Alfalfa, clover, and timothy hays cut at different times and cured under different conditions were found by the Ohio Station to—

contain significantly more vitamin G than vitamin B. The vitamin B and vitamin G content of the hays decreased as the plant matured and, in general, were correlated with the leafiness, greenness, and protein content of the plant. Exposure of alfalfa to the weather (day and night) for 96 hours—over half of which was sunshine—without rain, did not affect the vitamin G content. Rain (0.68 inch), on the contrary, removed as much as 50 percent of this vitamin. Timothy and clover cut early may have as high a vitamin G content as alfalfa cut later, and with a much greener color. * * * Ten percent of an alfalfa leaf meal containing 13 rat units of vitamin G per gram was required to induce good growth in chicks and prevent the occurrence of leg paralysis.

HORSES AND MULES

Increased interest in horses has made it necessary to inquire particularly into methods of feeding and management under changed economic conditions.

Feeding draft colts.—In determining the cheapest and best methods of raising colts to draft age, the Michigan Station found that colts fed limited winter rations made more rapid gains on alfalfa and June grass pasture than colts more liberally fed. However, the increased pasture gains did not entirely offset the greater winter gains made by the liberally fed colts. The station says:

Where cheap pasture land is available and if hay and grain are high, it seems advisable to limit the feed of colts in the winter time and to take more time for their development. On the contrary, when feeds are cheap and horses high, conservative or even liberal rations are advisable in order to hasten maturity, although extremely liberal feeding produces excess fleshing, which is usually unprofitable and makes the animal overfat for highest efficiency as a work animal.

The exercise needed for growing sound draft colts may be had by feeding out of doors in winter and by continuous use of pasture in summer. Because of danger of infestation by parasites, it is not advisable to pasture colts continuously on the same land. The station further found:

A limited ration of grain and alfalfa hay with free access to straw does not stunt draft colts but does retard development. A limited ration seems to have a greater effect on weight and condition than on skeletal development.

Diagnosing pregnancy in mares.—A biological method was developed by the California Station by which pregnancy in mares could be diagnosed in practically 100 percent of cases after the forty-fifth day of gestation. The test depends on the presence of a hormone in the blood serum of the pregnant mare which is detected by its influence

in causing precocious sexual maturity and ovulation after subcutaneous injection in immature rats. The results of other experiments suggest that the hormone in the pregnant mare originates in the placenta. The Michigan Station employed the rabbit for diagnosing pregnancy in mares, but positive results could not be obtained up to the forty-seventh day of gestation. The results were relatively accurate for the later stages of the gestation period tested.

BEEF CATTLE

Greater efficiency and economy in beef production is necessary in order to meet changing conditions. For this reason the experiment stations are bending every effort toward reduced costs.

Utilizing native grass pasture.—A method for producing finished beef more advantageously and profitably through a greater utilization of the native grass pasture was developed by the Kansas Station. The method consists of (1) wintering cattle well, (2) grazing the cattle during the first half of the pasture season, and (3) full feeding the cattle during the last 90 to 100 days in dry lot.

Alfalfa v. grain hays for calves.—Grain with alfalfa hay was one-third more efficient for fattening calves than the same grain with Albit wheat hay in experiments at the Washington Station. Equal parts of Albit wheat, Markton oats, and Horsford barley hay were equal in efficiency to alfalfa hay when fed with grain. The total digestible nutrients per 100 pounds of the chopped grain hays increased with the ripeness of the plant, but the palatability decreased. The optimum time of cutting, from the standpoint of feed value, seemed to be at the medium dough stage.

Citrus byproducts as cattle feed.—Dried grapefruit and orange canery byproducts were found by the Florida Station to be low in protein, fiber, and fat, but high in nitrogen-free extract, which was 88 to 92 percent digestible. These byproducts were found to be palatable to animals but had a laxative effect when fed as a large proportion of the ration. Dried grapefruit refuse had a generally favorable effect as indicated by thrifty appearance, glossy hair coat, and improvement in thickness of flesh. (See also p. 73.)

Ground flaxseed and soybeans as supplements to corn for fattening calves.—The South Dakota Station fed ground flaxseed and ground soybeans with shelled corn and alfalfa hay to fattening calves with considerable success. The animals receiving ground soybeans shed their coats earlier than those not receiving soybeans. Ground flaxseed was not a particularly palatable supplement. The calves receiving the oily feeds produced a large number of soft carcasses.

Relative profitableness of different grades of feeder steers.—As a result of studies at the Ohio Station, it was concluded that the man who grew the better grades of feeder cattle received a much greater return for them than was gotten by the man who grew the common ones. From the feeders' point of view, the plainer grades of grain-finished cattle will probably make their most satisfactory return when marketed during the late winter and spring season. The better grades of grain-finished cattle find a preferable market during the season when grass-fat cattle are available.

Soybean hay for feeding cattle.—In experiments reported by the Indiana Station, soybean hay gave approximately the same results as

clover hay when the ration was similar in other respects and consisted of corn, cottonseed meal, silage, and hay. A ration of corn, soybean hay, and silage did not produce as rapid gains as a similar ration to which had been added cottonseed meal. However, the cost of gain was enough lower with the former ration that the net profit was greater than when a supplementary feed was given. A ration of corn, oat straw, and soybeans produced slower gain and less finish on cattle than a ration of corn, cottonseed meal, corn silage, and clover hay; but the lower cost of gain enabled the cattle receiving the former ration to return a greater profit.

Feeding value of pinto bean culls and straw.—The New Mexico Station has found that as much as 4 pounds of pinto bean culls can be fed per day to steers weighing 500 or 600 pounds without causing them to scour, but that larger amounts cause scouring. The feeding value of pinto bean straw apparently depends on the method of harvesting and to a larger extent on the quality of beans remaining in the straw after threshing. A good feed for wintering cattle may be provided by mixing one part corn, milo, or hegari (grain) with four parts of the poorest pinto bean straw. The better pinto bean straws and those which contain more of the bean culls need but little, if any, grain added to make a feed which will carry the cattle in good flesh through a winter or a drought.

Effect of feed on quality of beef.—A study in which as much as 22 percent of the oil content of one steer's ration was derived from menhaden oil, and as much as 27.5 percent of the oil content of another steer's ration from coconut oil did not produce any apparent difference in the color of the meat or the firmness of the carcass at the Iowa Station. This amount of ingested oil was not sufficient to influence adversely the flavor of the roasted beef. Repeated experiments at the West Virginia Station have demonstrated that grass does not produce dark-colored beef. In general, better finished beef had a lighter color. Two-year-old steers were sufficiently finished on grass with relatively small amounts of a grain mixture of six parts corn and one part cottonseed meal to produce excellent carcasses for the market.

DAIRY CATTLE AND DAIRYING

Scientific research has placed dairying well in the forefront of agricultural activities. Through unbiased study radical ideas are developed into commonplace facts, new and better methods are discovered, and better equipment is invented to bring greater profit and satisfaction to all.

Improving pastures for dairy cattle.—The New Jersey Station found that in spite of general neglect the pastures of that State produce 6 to 8 million dollars' worth of feed yearly at a negligible cost in labor and materials. A system of pasture management to secure high-quality feed at low cost was worked out. In general, this system consisted of dividing pasture land to permit rotation grazing, treating with commercial fertilizer every 2 or 3 years, and manuring. Supplying temporary grazing during the normal midsummer pasture shortage and in the late fall, in addition to the above system, makes barn feeding a minor operation during the grazing season of 5 to 7 months. The system is advised only for farms having sufficient livestock and facilities to utilize all the feed produced.

Cows produced more milk on wheat pasture in early spring at the Ohio Station than during a like period of liberal barn feeding and a subsequent period on good bluegrass pasture.

Citrus byproducts feed.—Dried citrus refuse (peel, rag, and seed of both oranges and grapefruit from citrus canneries) were found by the Florida Station to have a food value about equal to that of dried beet pulp. It was a palatable feed, and neither the fresh feed nor the dried product when fed in limited quantities affected the flavor of milk. (See also p. 71.)

Mineral supplements for dairy rations.—The Pennsylvania Station finds that, contrary to popular belief, mineral supplements, other than common salt, are not needed for milk production if the cows receive normal amounts of roughage. Mineral supplements may be necessary when the ration is abnormally low in calcium or phosphorus. This information should save much money which is now annually expended for mineral supplements in dairy rations. Investigations at the Massachusetts Station indicated that rations containing 1.8 grams of phosphorus daily per 100 pounds of dry weight during the first year of life, 1.79 grams during the second year, and 1.2 grams during the third year, were sufficient to maintain normal growth and production in dairy cattle. When the roughage consisted of inferior quality mixed hay, some additional source of phosphorus appeared to be necessary.

Roughages for dairy cows.—In a study at the Vermont Station of the feeding value for dairy cows of artificially dried young Sudan grass, it was found that the dried grass contained 9 percent digestible crude protein and 58.8 percent total digestible nutrients on the basis of 86.4 percent dry matter. The results also indicated that as a sole feed for dairy cattle the dried young grass may be deficient in calcium. At the Oregon Station, cows receiving alfalfa hay alone were less efficient in producing milk and converting the digestible nutrients in the feed into digestible nutrients in the milk than were those receiving grain supplements in addition to the hay. The low production on alfalfa hay alone apparently was due to the lack of a sufficient consumption of total digestible nutrients and probably of phosphorus, to maintain production at a high level. The Arkansas Station finds that a ration of white corn and rice byproducts fed with a roughage of prairie hay, in the absence of green pasture, was very low in vitamin A and that legume hays should replace the prairie hay if maximum production and normal reproduction are to be obtained.

Silage for dairy cattle.—A group of cows fed acid-preserved silage, known as A. I. V. silage, as the sole roughage was compared with a similar lot receiving an equivalent amount of dry matter in chopped hay at the Ohio Station. There was little difference in production between the lots. No significant change was noted in the alkaline reserve of the blood. The vitamin A and carotene values per unit of butterfat produced were almost identical for the two groups. The milk from the silage-fed cows seemed to support somewhat better growth in rats than that from the hay-fed groups, but the difference was not great.

Sweetclover silage was found by the Idaho Station to be practically equal to corn silage as measured by milk and butterfat production

and body weights of the cows. In the upper part of the silo the sweetclover silage was dark in color and had a characteristic coumarin odor. As it was fed off, the silage improved in quality and the bottom half was greenish yellow in color and had a clean, silage odor. This silage was not as palatable as corn silage, but cows ate it readily when they became accustomed to it. It did not impart taints to milk or milk products.

Dairy cows with drinking water constantly before them, the Connecticut (Storrs) Station observed, adjusted their hay consumption to the quantity of dry matter consumed in silage. The total roughage dry matter consumed was not greatly affected either by the quantity of silage or the proportion of water in it. The total roughage dry matter consumption, when the animals had constant access to water, was not affected by succulence of the rations. Animals watered only once a day consumed appreciably less hay than animals continuously supplied with water. The addition of silage to the rations of animals receiving water once a day did not increase the consumption of roughage.

Cottonseed meal for dairy cows.—Jersey cows fed a heavy cottonseed meal ration produced milk that scored slightly higher for flavor than milk produced on a normal ration at the Oklahoma Station. Milk produced on a ration of cottonseed meal and prairie hay was normal in every way except that it lacked in yellow color. This deficiency may have been due to the fact that the cows were kept in dry lot and that the hay fed was not very green in color. Ice cream, cottage cheese, and Cheddar cheese were made from this milk without any variations in process of manufacturing or quality of products. About 50 percent longer time was required for churning, or if the churning time remained normal the cream had to be churned at about 6° F. higher temperature and the wash water used had to be warmer. The cottonseed-meal butter scored about 0.7 of a point lower than normal butter and somewhat more butter color was required. It was found that calves could be raised from birth to maturity on whole milk and skim milk during the first 6 months and a basal ration of prairie hay and cottonseed meal. No symptoms of vitamin A deficiency developed even when a very low grade of prairie hay was used and at no time was there evidence of a low level of calcium or inorganic phosphorus in the blood. Substituting dried beet pulp for the prairie hay produced the characteristic symptoms of so-called cottonseed-meal injury.

It was evident that prairie hay of average quality contained sufficient vitamin A or other dietary factors to correct the deficiencies of cottonseed meal. As a result of extensive studies at the New Mexico Station, it was concluded that cottonseed meal could be used safely as the principal source of protein for dairy animals if fed with a good quality roughage.

Tankage for dairy cows.—The Massachusetts Station found that high-grade tankage can be safely added to the list of protein feeds for dairy cows, provided the usual precautions for feeding protein concentrates are observed. In addition to its protein, tankage carries a considerable amount of bone, which can take the place of the bonemeal so often added as a mineral supplement to mixed feeds.

Increasing the fat content of milk.—The Minnesota Station found that butterfat production can be greatly increased by increasing the

fat content of the ration. Apparently the fat of a ration may have greater value for production of milk fat than is indicated by the commonly used feeding standards. On the other hand, the New York (Cornell) Station tentatively concluded that for feeding practice a level of 4 percent fat in a grain mixture, fed at the rate of 1 pound for every 3 to 3.5 pounds of milk, together with adequate amounts of hay and corn silage, may be considered substantially adequate for butterfat production. A higher level is not justified if it increases the cost of the ration per unit of total digestible nutrients.

Breeding experiments have been under way at the New Jersey Station to demonstrate the possibilities of increasing the butterfat content of Holstein milk. An inbred heifer exceeded her dam's average fat test by 0.3 percent and that of the breed average by 0.66 percent.

Mammary development and function.—The factors underlying milk secretion have long been baffling. Studies at the Missouri Station showed that proliferation of the mammary gland, as it occurs near the end of gestation, could be induced in virgin heifers and rabbits by injection of a hormone from the follicle about the developing ovum. Mammary glands of such animals could be brought into active secretion within 3 days by the administration of galactin, a hormone of the anterior lobe of the pituitary gland. Injections of the same hormone into poor-yielding milk goats late in lactation at the New York (Cornell) Station caused an increase in milk production and persistency.

Breeding and performance.—The Iowa Station conducted a number of experiments with dairy cattle, involving especially the influence of inbreeding and cross-breeding on Holsteins and a study of the breeding practices followed in the development of the pure breeds of livestock. A statistical analysis of milk records indicated that three methods may be employed in selection based on pedigree, performance, and progeny test. As the early selections were based on pedigree, the chances of improvement by this method are more nearly exhausted and the chances for further gains appear most likely from selection based on performance or progeny tests.

Machine v. hand milking.—Cows milked by hand produced slightly more milk than those milked by machines in a comparison at New York State Station. The difference in production was evident only after the third month of the lactation period. The hand-milked cows were more persistent in maintaining production throughout the lactation period. This fact was believed to be due to the relatively long time the machine was left on the cows and indicated the desirability of removing the machine from the cow as soon as possible. These results were not interpreted as being adverse to the use of milking machines, but rather emphasize the need for correct operation.

Milk of constant composition and quality.—The Ohio Station concluded that a cow tends to produce milk of constant composition, despite adverse conditions of feed and management. The quantity of milk may be reduced by adverse conditions, but the composition is likely to remain unchanged even if the cow has to draw upon its bodily reserve for the purpose. The food value of the milk is

not materially affected by radical differences in the protein content of the cow's ration.

Controlled milk production.—The Maine Station found evidence of milk-production control in the fact that the number of cows in New England had increased only 7.7 percent from the low point in 1929 to January 1, 1934, whereas the increase from the low point for the United States as a whole was 17.8 percent. The States outside of New England supplied only 22 percent of the total amount of cream received in Boston in 1930, but this figure increased to 38 percent in 1931, to 42 in 1932, and to 44 in 1933. It was evident that New England dairymen had controlled their sales of milk and cream, in spite of an increase in cow numbers, and had surrendered an increasingly greater proportion of their cream market to the Midwest. Another indication of milk-production control was shown in the fact that in 1928 an average of 44.6 percent of milk delivered through the New England Milk Producers' Association was sold as surplus milk, whereas in 1933 only 31.4 percent was sold as surplus. Further, a smaller proportion of the total milk delivered was converted into cream or manufactured dairy products. In 1933 Maine supplied only 11.7 percent of the total milk and cream received in Boston and the metropolitan area, as compared with 12.4 percent in 1930.

Consumption of milk.—From a recent study of the Buffalo milk market, the New York State College of Agriculture found that both rises and falls in retail prices of milk by stores brought about less than proportional changes in volume sold. A one-third drop in price, from 9 to 6 cents a quart, resulted in less than one-fifth increase in sales, whereas a two-thirds increase in price resulted in only a one-seventh drop in sales. The conclusion was reached that—

since greatly increased sales of milk through stores appear to be predicated upon sharply lowered retail prices, retail stores in upstate cities do not appear to be an outlet for milk worthy of extended effort on the part of the New York State dairymen.

Soft-curd milk.—The Pennsylvania Station found no qualitative difference between soft-curd and hard-curd milk and a significant quantitative difference only with respect to the amount of casein. Soft-curd milk had no inherent characteristics which would warrant the statement that its ingredients are more easily digested than those of hard-curd milk. The differences in digestibility appear to be explainable almost entirely on the basis of the higher casein content of the hard-curd milk. Soft-curd milk is broken down and eliminated more rapidly in the stomach of humans, calves, and rats than is hard-curd milk. The curd tension of normal, untreated milk varies with season and stage of lactation and can be artificially reduced by diluting, boiling, homogenization, and reducing the acidity. Mastitis infections cause a lowering of the curd tension.

Off flavors and odors in cows' milk and milk products.—Off flavors and odors in milk and other dairy products constitute one of the most serious problems of the dairyman and the milk dealer. The California Station says that if the consumption of fluid milk is to be maintained, the product must be kept uniformly palatable from day to day. The station has determined the causes and prescribed remedies for many of the distasteful flavors and odors. For example,

it has found that various feeds such as alfalfa hay, green alfalfa, clover hay, corn silage, or musty hay may, if fed in too large amounts shortly before milking, impart undesirable odors and flavors to the milk. On the other hand, wheat bran seemed to improve the flavor of the milk when fed in 5.5- to 7-pound quantities 1 hour before milking. It gave more flavor to the milk than was present in the control samples, and the flavor was reported as pleasing. Salty taste was observed in milk from certain cows that were advanced in lactation and also from one or more quarters of udders previously affected with mastitis. Rancid milk was produced by certain cows that had been milked for longer than the usual lactation period. Oxidized flavor develops in milk that has been in contact with certain corrodable metals. Copper and its alloys have been found to be the most common cause of oxidized flavors. Exposure to sunlight also causes an oxidized or tallowy flavor.

Feed flavor was observed by both the New York State and the Oklahoma Stations more often than other defects. In most cases, feed flavors develop in milk only when the feed has been consumed a few hours before milking. For this reason it is advisable to feed highly flavored feeds immediately after milking.

Bitter and other abnormal flavors in milk, cream, and butter were found by the New York (Cornell) Station to be due to milk lipase. These defects may be largely eliminated, in the case of cream and butter, by prompt pasteurization of the cream.

Goat's milk flavors.—The growing interest in goat's milk as a food has led the New York State Station to make a study of flavor and other factors which affect the nutritive value of such milk, in which a large number of samples of the milk entered by producers in a scoring contest were examined. There was shown to be a definite relationship between the quality of goat's milk and its composition. The station found that the higher the sugar content the better the flavor of goat's milk, while just the reverse was true with respect to the salt content of the milk. There appeared to be no significant relationship between the flavor and the fat and total solids content of the milk.

Increasing the vitamin D potency of dairy products.—The more important methods that have been proposed for increasing the vitamin D content of milk are feeding cows irradiated yeast, irradiating the milk, and adding vitamin D concentrates to the milk. In studying the relative merits of these methods, the Ohio Station found that the feeding of irradiated yeast had the advantage of increasing the vitamin D content of milk through the cow without further tampering with the milk. An outstanding advantage of direct irradiation of the milk was the mechanical control which it afforded, thus reducing to a minimum the human element of an error. The method is subject to adverse reaction of the consumer against additional handling processes. The direct addition of vitamin D concentrate had the advantage of ease and flexibility of application, but was also subject to unfavorable psychological reaction of the consumer, and was in conflict with regulations controlling the production and sale of milk. The station felt that before any method was adopted for general use the different processes and equipment should be carefully standardized and some means devised to assure the consumer that he gets the expected product.

Effect of homogenization on milk.—Because the homogenization or viscolization process is being used to an increasing extent in the market-milk industry, the Michigan Station undertook to determine the effect of the process on some of the properties of milk. The process increased the viscosity of raw milk and decreased the viscosity of pasteurized milk. It decreased the foaming ability of raw milk but increased that of pasteurized milk. It favored sedimentation in milk. Cream homogenized at 900-pound pressure per square inch churned more completely when ripened than when not ripened. Rancidity always developed in homogenized raw milk, particularly with higher pressures of homogenization. The process did not impair the flavor or color of milk pasteurized previous to homogenization. Homogenized and clarified milk after pasteurization yielded a product which had none of the major defects incident to the process, such as rancidity, increased acidity, and sediment.

Carotene as a butter color.—The use of carotene as a butter color was found by the Ohio Station to increase the vitamin A content. As indicated by the growth of rats, 60 milligrams of uncolored winter butter, 45 milligrams of carotene-colored butter, and 30 milligrams of June butter were equal in vitamin A content.

Improving ice-cream manufacture.—Investigations relating to ice-cream manufacture, which have been of benefit to producers of milk and of other ingredients of ice-cream manufacture, to the dealer, and to the consumer, have been a feature of experiment station work. Some recent contributions to this important subject are: Causes of off flavors, such as copper contamination and milk-fat oxidation, have been detected and their remedy suggested by the Iowa and Pennsylvania Stations; improvement of strawberry ice cream by the Illinois and Massachusetts Stations; improved methods of freezing fruit for use in ice cream and sterilization of freezers by the New York State Station; use of sodium caseinate as a stabilizer by the Iowa Station; homogenization of milk and cream for use in ice cream by the Pennsylvania Station; preparation of high-fat ice cream and intensifying the action of gelatin by the Massachusetts Station; sterilization of dairy utensils by the Illinois, Kansas, and Michigan Stations; and pasteurization of ice-cream equipment and mixes by the Ohio and Pennsylvania Stations.

Roquefort-type cheese.—The Minnesota Station successfully ripened this type of cheese made from cows' milk in caves in sandstone bluffs along the Mississippi. The Iowa Station also succeeded in making from cows' milk a Roquefort type of cheese which appeared to have promising commercial possibilities. A yield of 2.27 pounds of cured cheese per pound of fat in the milk was obtained. The estimated total cost of manufacture, exclusive of milk, was 11.38 cents per pound of cheese.

Effect of pasteurization on decomposition of Cheddar cheese.—Cheese made from pasteurized milk showed a marked break-down of protein in experiments reported by the Iowa Station. After 2 months' ripening, the flavor of cheese made from raw milk was uniformly better than in cheese made from pasteurized milk. The latter cheese was generally characterized by a lack of flavor and a tough, rubbery texture.

Acidity in the manufacture of cream cheese.—As a result of its investigations, the Wisconsin Station has suggested modifications which

apparently shorten cheese-making operations without injuring the quality of the cheese. The results indicated that by using 5 percent of starter, 3 cc of rennet per 1,000 pounds of cream, and setting at 90° F., it was possible to complete the cheese-making process in 1 day without injuring the quality of the cheese. The cheese was almost invariably dry and crumbly when the acidity of the cream at the time of cutting was less than pH 5.0. When the acidity at cutting was greater than pH 4.8, the cheese was usually very smooth in texture but acid in flavor.

Clean dairy plants.—A large part of the success of the dairy industry depends upon the confidence of the consumers that they are receiving clean and wholesome products. It is no easy matter to build up and maintain this confidence. In spite of the large amount of attention the problem has been given and the great advances made, the Michigan Station shows that proper cleansing equipment is one of the least understood processes and is one of the most important. Often, the operator is unacquainted with the composition of the cleaner he is using. Even the degree of hardness of the water he is using may be unknown to him, although this has an effect on the efficiency of his washing powder. The alkalinity of the cleaner and its abrasive effect may be destructive to the plating on his equipment, and again, a cleaner suited to one type of cleaning may be very unsatisfactory for other types.

Marketing milk and cream.—In a detailed survey of marketing of milk and cream in secondary markets of Massachusetts, the Massachusetts Station collected from every dealer and producer distributor operating in the surveyed territory data as to the daily receipts and sales of milk and cream, retail and wholesale prices for different grades, milk-purchase plans in relation to producers, number and location of producers, and quality of product. As a result of this survey a clear picture was obtained of the marketing set-up in each important community of the State. The State Milk Control Board, in starting its operations in the fall of last year, found the results of the survey of great importance in planning its initial operations in the various sections of the State.

Hogs

Swine continue to be the main source of meat in the country. They are also the chief means of marketing grain. In order to keep the consumer supplied with as cheap a product as is consistent with a fair return, the producer is faced with varied problems of breeding, feeding, management, and marketing. The experiment stations are helping the producer to meet these problems.

Swine types and consumer demands.—In studying the various types of hogs with reference to consumer demands, the Illinois Station found that the intermediate type most nearly approached the ideal. The chuffy, the rangy, and the very chuffy types followed in the order named. The ideal hog would have the quality and plumpness of the intermediate type, the length of the rangy, and the early maturity of the chuffy.

Inheritance of abnormalities.—From time to time swine breeders are faced with problems of abnormal or off-type characters in their pigs. In order to eliminate these defects, it is necessary to know the mode

of their inheritance and to be able to trace the trouble to the animals transmitting the abnormalities in the breeding herd so that they may be discarded. In this connection, four pigs with defective skulls appeared among 159 farrowed in sire-daughter matings at the California Station. A characteristic kinky tail and inverted nipples, which rendered the mammary gland nonfunctional, were observed by the Idaho Station. This station also found that through inbreeding of Duroc-Jersey swine, white coloring appeared on the feet, legs, tip of tail, forehead, and in the form of incomplete belts over the shoulder and rump in some of the progeny. The manner in which these defects were inherited was worked out and recommendations for their prevention made available.

Inbreeding of swine.—Over a period of years the Oklahoma Station has found that inbred hogs are more uniform than outcrosses but are less thrifty and more subject to disease. It required more feed to produce a given gain with inbred hogs than with outcrosses. Fewer inbred hogs per litter were raised to marketable age.

Cross-breeding swine.—Stockmen recognize that cross-bred animals possess distinct advantages over purebred or high-grade animals for commercial purposes. Denmark has made large and profitable use of cross-breeding in pork production. Cross-bred animals are generally more vigorous and productive than purebreds. The Minnesota Station has found cross-bred sows superior to purebreds for producing market pigs. The resulting pigs benefited as much from being out of cross-bred sows as they did from being cross-breds themselves. These results are based on crosses in which boars from one breed are mated with cross-bred sows from two other breeds.

The cross-bred litters averaged from one-third pig to two pigs larger at weaning; on the average, each pig weighed from 5 to 7 pounds more at weaning, and the litters weighed from 39 to 96 pounds more than the purebreds. The cross-bred pigs reached a market weight of 220 pounds from 17 to 22 days earlier than comparable purebreds, and they reached that weight on from 27 to 36 fewer pounds of grain. A new method of breeding market swine, labeled crisscrossing, is recommended as a result of this experiment.

Feeding the brood sow.—When pregnant sows were fed, at the Oklahoma Station, a ration containing as little as 10 percent protein, the young produced were approximately 16 percent lighter at birth than the young of females that had been fed a ration containing 16 to 20 percent protein. Regardless of how well the sows were fed during the lactation period, pigs stunted during the period of gestation never fully recovered. Barley fed as the sole source of vitamin A was found by the California Station not to contain enough of this vitamin for normal reproduction in the pig. The addition of salt, calcium carbonate, and casein to the barley did not prevent all the outward symptoms of vitamin A deficiency.

Raw rock phosphate containing fluorine proved quite unsatisfactory when used in the mineral mixture for brood sows, in experiments reported by the Ohio Station.

Cost of raising pigs to weaning age.—Experiments at the Alabama Station indicated that the cost of raising pigs to weaning age was determined to a very large extent by the size of the litter. The average amount of concentrates required to raise a pig to weaning age in a litter of two was 448 pounds, but in litters of nine it was only

110 pounds. In this experiment the feed cost of raising the pigs in litters of two was \$9.36 each, and in the litter of nine it was \$2.29.

Pastures for pigs.—Pasture tests by the Arkansas Station indicated that Sudan grass excelled cowpeas, sweetclover, soybeans, sorgo, Bermuda grass, and turnips as a pasture crop for growing and fattening pigs, self-fed corn, and either tankage and minerals or minerals alone. The Sudan grass was most useful and furnished richer and more palatable grazing for the pigs when it was kept cropped not to exceed 10 inches in height. Sudan grass is ready for grazing in 3 weeks from the time of planting and may be used to furnish excellent grazing from the middle of June until the first killing frost.

Grinding grain for hogs.—The Florida Station found that grinding corn to a medium degree of fineness increased the digestibility of the protein by 13 percent, but the digestibility of the gross energy of the corn was raised only 2.8 percent. The metabolizable energy was only slightly improved. The appreciable advantage in protein digestibility occasioned by the grinding of corn was largely lost by greater losses of nitrogen incurred in metabolism, so that the net effect of grinding upon the nutritive value of corn for this experiment was to increase its value as a source of energy.

In experiments to determine the best method of preparing such grains as kafir corn and wheat for hog feeding, the Oklahoma Station found that while the best gains were secured by grinding, when the cost was taken into consideration, in most cases it was just as economical to feed these grains whole.

Protein supplements for swine.—Tankage and linseed meal proved to be more economical supplements to a ration of corn, alfalfa hay, and minerals than ground flaxseed in experiments reported by the Minnesota Station. Ground flaxseed was more efficient when fed with tankage than when fed as the only protein supplement. When fed as a supplement, ground flaxseed tended to produce soft pork. Under ordinary conditions, it would be more economical to sell flaxseed and buy other protein supplements for fattening pigs. The Ohio Station found that the oil meal resulting from 100 bushels of soybeans when combined with corn would produce more gain on pigs than the 100 bushels of beans when fed with corn, and the danger of soft pork was eliminated when the oil meal was fed.

Effect of soybeans on quality of pork.—An objection raised to the use of soybeans or soybean oil meal in feed for pigs is that they produce soft pork. From results of a series of experiments in which these feeds were used, the Indiana Station concludes that the quality of either fresh or cured pork from hogs fed corn and soybeans may be as satisfactory as that from similar hogs fed corn and tankage, or corn and soybean oil meal, provided certain definite restrictions are placed on the feeding of the soybeans: If the pigs are to be fed on pasture, they should not receive soybeans until they weigh 75 pounds; if the pigs are to be fed in dry lot, they should not receive soybeans until they reach a weight of 125 pounds; soybeans should not be fed as a substitute for corn; rather, they should be used as a supplement to corn. From the standpoint of practical application of this principle, 14 percent is considered the maximum quantity of soybeans to

be used in the ration. If the above precautions are not taken in the feeding of soybeans, hog raisers are likely to produce pork that is unsatisfactory both to the packer and to the consumer.

Soybean pasture for fattening hogs.—In experiments reported by the Maryland Station, the addition of soybean pasture to a self-fed ration of shelled corn, digester tankage, and minerals resulted in a 9.14 percent greater gain in weight; a 31.1 percent smaller consumption of tankage; a 2.38 percent greater consumption of feed, aside from forage; and a 6.2 percent smaller amount of feed, aside from forage, required for the production of 100 pounds of gain in weight. Soybean forage did not prove to be an adequate single supplement for shelled corn and minerals.

Forage for swine.—The Ohio Station finds it worth while, from the standpoints of health, growth, and economical production, to provide pasture for pigs. Alfalfa was found to be unsurpassed for this purpose among the crops tried, including, in addition to alfalfa, red clover, alsike clover, dwarf Essex rape, soybeans, Sudan grass, sweet-clover, wheat, and bluegrass. Rape ranked high as an annual forage crop for pigs. Soybeans compared favorably with red clover and rape. Sudan grass produced an abundance of fairly palatable forage, but was not equal to such crops as rape or soybeans. Sweet-clover was distasteful to the pigs. Results with spring-sown winter wheat were not entirely satisfactory for various reasons. Bluegrass proved to be a good early pasture. "During the summer months, however, it showed a relatively low value. If other hogs have been on it a year or two previously, bluegrass may have become contaminated with roundworm eggs and be objectionable on this account." Protein and mineral supplements appeared to be necessary in most cases. Minerals were beneficial for feeding with corn and protein supplements of plant origin.

Feeding young pigs.—Young growing-fattening pigs gained more rapidly up to a weight of 75 pounds on pasture than in dry lot in experiments reported by the California Station. The evidence suggested that the vitamin A content in the forage was an important factor in the greater gains by pigs having access to pasture. Pigs that had been on pasture gained more rapidly while fattening in dry lot than those which had not received green forage during their early life. Pigs fed during the summer and early fall required less feed per unit of gain than similar pigs fed through the late fall and winter months.

Marketing of Corn Belt hogs.—The Illinois Station finds that local markets have diverted much packer buying away from terminal markets because they are able to deliver hogs to packers cheaper than terminal markets can supply them. The station says that—

since local markets operate at a definite differential below terminal markets, it is likely that they will continue to undersell the terminals and that, barring the appearance of some new factor in the situation, the terminal markets will continue to give way to the local marketing system. Too few stockmen realize the rapidity with which decentralization in livestock marketing has been and is taking place. Only as they become aware of this decentralization and its attendant problems, and take effective steps to coordinate their selling operations can they expect to overcome their present disadvantages and put themselves in position to bargain effectively with the meat-packing and meat-distributing groups.

SHEEP

In attacking the problems relating to sheep, the experiment stations are developing improved methods of management, feeding, and marketing of sheep and wool. Studies are also conducted on improving the quality of the carcasses and fleeces of sheep by selective breeding.

Improved sheep for Florida.—In cooperation with the Department of Agriculture, the Florida Station reports that the wool clip of Columbia sheep, brought from Idaho to Florida in 1933, has not decreased progressively with the length of time the sheep have been in the warmer climate. The fleece weight for ewes averaged 14.1 pounds in 1935, an increase of 8 percent over 1934, when reduced to a uniform period of growth and for exactly the same ewes.

Breeding ewe lambs.—Breeding ewes to lamb as yearlings did not interfere with their normal growth and development at the North Dakota Station. This practice resulted in a significant gain in number and total weight of lambs produced during the normal breeding life of a ewe.

Grading-up sheep.—The use of Corriedale rams on native Hampshire grade ewes increased the yield of good quality wool as much as 80 percent in the first cross offspring in experiments at the West Virginia Station conducted in cooperation with the Department of Agriculture. The crosses also showed good carcass quality.

Hornless sheep.—The Texas Station has found that the polled character in Rambouillet and Merino sheep is dominant over the horned character. Rams whose male offspring are 100-percent polled have been identified. The breeding potency of the hornless ram is sometimes less pronounced than that of the horned ram, but the station does not consider this defect necessarily correlated with hornlessness. Ridgling ram lambs are commonly found in polled Rambouillet flocks. This defect is popularly believed to be linked in some way with the polled character. The work at the station shows that this defect is recessive and not necessarily associated with hornlessness.

Physiology of reproduction in sheep.—The principle underlying the practice of flushing in sheep was investigated by the Minnesota Station. Ewes in a relatively thin condition when subjected to this treatment produced 1.4 ova per ewe as compared with 1 ovum per animal for similar ewes not so treated. For ewes in a relatively high condition, flushing tended to decrease the number of ova produced. It was concluded that the condition of the ewes determines whether or not the practice should be followed. The relation of the thermoregulatory function of the scrotum to practical breeding operations with rams was studied at the Missouri Station. It was found that the muscles of the scrotum relaxed with temperature increases and contracted with temperature decreases. By regulating the position of the testicle in relation to the distance from the body, a constant temperature of the testicle is maintained. Two sterile rams in high condition with a heavy covering of wool over the scrotum were restored to normal fertility after lowering their condition and shearing the scrotum.

Sorghum for feeding lambs.—Studies at the Kansas Station have shown a new outlet for sorghum crops as feeds for fattening lambs for market. The new outlet is of considerable significance in the

dry-land farming areas of the western part of the State where it has been found possible to fatten range lambs for market advantageously by utilizing sorghums.

Self-feeding of lambs.—In experiments extending over a number of years, the Oklahoma Station has found that, when properly managed, lambs can be fed satisfactorily with self-feeders. The risk with this method of feeding is somewhat greater than with hand-feeding.

Tankage for sheep.—Sheep fed equal parts of tankage and barley made as good or better gains than those fed an amount of barley equal to the combined weight of barley and tankage, in experiments reported by the North Dakota Station.

Quality of wool of different breeds of sheep.—From studies of fleeces of Oxford, Southdown, Hampshire, Shropshire, Dorset, and Rambouillet sheep, the Oklahoma Station concludes that breeders of mutton sheep who have about average flocks can afford to give more attention to crimp, fineness, and length of fleece, and that breeders of fine-wool sheep with average flocks can well afford to give more attention to length and at the same time insist on stud rams having a high count of crimp. Since diameter of fiber and length tend to increase together and crimps increase with fineness, it is apparent that selections based on length alone should result in coarser wool with a decrease in the frequency of crimps.

POULTRY

The stations have continued their activities in poultry research by conducting studies in breeding for improved birds, improved methods of care, feeding, and management, and the production and marketing of products of higher quality. Investigations into the more fundamental phases of the industry also receive considerable attention.

Physiology of reproduction in the domestic fowl.—Studies by the Kansas Station have revealed that the yolk-white ratio in hens' eggs is very definitely fixed for the individual birds, but that birds differ rather widely with respect to the proportion of these two constituents of eggs. The mean ratio of white to yolk was found to differ as much as 1.5 to 1 and 3 to 1 among individual birds. The variations in size of eggs were due to fluctuations in yolk size. The hen increased the amount of white in proportion to the increase in yolk size, keeping the yolk-white ratio constant. However, all hens do not secrete the same amount of white for the same yolk size. Measurements of the oviduct, the duct in which the egg is formed, show that there is a relatively close association between the yolk-white ratio and the oviduct length. The hens with the longer oviducts produced eggs with higher proportions of white to yolk. Studies on hens from different breeds have shown that some types differ widely in their yolk-white ratio and the difference may be accounted for largely by differences in oviduct length. Observations at the same station on the anaesthetized hen showed that ovulation occurred within 1 hour after laying. By marking the position of the egg at 15-minute intervals in its passage down the oviduct, it was found that a little more than 24 hours was required for the egg to progress from the ovary to a stage at which it was ready to be laid.

Effects of inbreeding in poultry.—The Massachusetts Station found that inbreeding increased range mortality, retarded sexual maturity, increased the percentage of birds with winter pause, reduced intensity, had no effect on broodiness, decreased persistency, reduced hatchability, increased winter egg weight, consistently reduced annual egg production without reducing its variability, and increased laying-house mortality. In no respect were the inbreds or inbreds crossed found to be superior to the general flock. Apparently nothing is to be gained from the standpoint of fecundity by inbreeding.

From many years' data on inbreeding and cross-breeding of the White Leghorn, the Iowa Station concludes that intense inbreeding (35 to 85 percent) does not necessarily decrease the average fertility, decrease the average hatchability, increase the average days to sexual maturity, increase the mortality of chicks up to 24 weeks of age, decrease average egg production, decrease rate of growth, or retard the ultimate adult weight of the bird, and in the station's study neither increased nor decreased the average egg size.

Sex determination of day-old chicks.—Through appropriate crosses of birds carrying sex-linked characters, it is possible to identify the sex of the chicks at hatching. However, such birds are cross-bred and not suitable for interbreeding. A method of sex determination in chicks at hatching, based on the presence or absence of the rudimentary copulatory organ in the vent of the newly hatched chick discovered in Japan, has been described by the New Jersey Station. As experience is gained in this method of sex determination, day-old chicks may be sexed quite accurately.

Breeding production and exhibition Rhode Island Reds.—Exhibition and production strains of Rhode Island Reds purified through inbreeding at the Massachusetts Station were crossed to study the behavior of the fecundity and plumage characteristics in inheritance. Study of the data indicates—

that hybridization increases body weight; * * * that early sexual maturity dominates late sexual maturity; that high intensity depends on dominant genes; * * * that persistency is lowered by crossing; * * * and that annual egg production is above intermediate between the two parent stocks in the first hybrid generation and tends to decrease in the F_2 generation.

The characteristics of the plumage suggest the dominance of modifiers for light color carried by the production strain. The exhibition stock carried the factors for the desired characteristics for show purposes, whereas the production stock carried factors for high productivity.

Fish meal as a poultry feed.—The Ohio Station, cooperating with the Department of Agriculture, has studied the nutritive value for chicks of fish meals of different kinds prepared in various ways. It was found that the protein of the meal was significantly better than that of meat scrap for promoting growth in chicks, but that there was some loss of the antipellagric G complex in certain processes of preparing the meal, namely, cooking and centrifuging before drying, and drying at a high temperature. Meal prepared from haddock heads and tails was found to be higher in vitamin G than that prepared from the edible portions of the fish, but poorer in proteins. Experiments with rats showed that high drying temperatures, as in flame drying, significantly lowered the digestibility of the protein

in haddock meal. The protein of vacuum-dried haddock meal was superior to that of flame-dried meal.

Vitamin A for poultry.—Studies by the New Jersey Station showed that the vitamin A content of the yolk of eggs laid by birds receiving what was considered an adequate diet did not decrease during the laying season. An increase of vitamin A in the ration may be accompanied by an increase in food consumption and egg production but by a loss in body weight. In view of the high mortality of birds in heavy production, it is suggested that there is a possibility of undue stimulation by excess of some dietary factor, possibly vitamin A. At the New Hampshire Station it was found that rations containing 0.5 percent of sardine oil were as efficient as those containing 1 percent of cod-liver oil. Since sardine oil is considerably cheaper than cod-liver oil, the saving to the feeder is apparent.

Vitamin D for poultry.—Considerable variation in the antirachitic effect of sunshine on chicks was demonstrated by the New York (Cornell) Station. It was shown that the minimum daily exposure to sunshine required to prevent rickets in chicks at Ithaca was approximately 30 minutes in winter, 5 minutes in spring, and 2.5 minutes in summer, when the exposures were made behind glass which transmitted practically all the ultraviolet rays of sunshine except those lost by reflection. The Pennsylvania and Washington Stations have found that laying hens require twice as much vitamin D, which commonly is supplied by adding cod-liver oil to the ration, as do growing chicks. Breeding hens required an even higher level of vitamin D in order to secure maximum hatchability of eggs. A deficiency of vitamin D reduced the size of the eggs and resulted in poor shell quality. On the other hand, the New Jersey Station has reported results of experiments which threw some doubt on the importance of feeding cod-liver oil to hens which have access to sunlight except possibly during winter months when there is a deficiency of sunlight.

Effect of light on egg production.—The Ohio Station found that artificial lighting, in addition to inducing birds to consume more feed and lay more eggs, also appeared to have a direct influence in stimulating egg production. In a comparison of white, red, yellow, and blue lights, it was observed that red light had the greatest influence in stimulating feed consumption and assimilation and in increasing production. Blue light had the least influence in increasing production.

The influence of green feed on quality of eggs.—Green feed as a supplement to a standard basal laying ration showed very little influence upon the average grade of eggs going into storage or upon the loss in average grade during a storage period of 235 days, in experiments reported by the Arkansas Station. The average grade ⁵ into storage of eggs which were produced on a basal ration plus green feed was 1.25 as compared to an average grade of 1.27 for the eggs which were produced on the basal ration alone. The average grade out of storage for these eggs was 2.95 for the green feed lot and 2.84 for the control lot. Time of holding eggs before storing had a de-

⁵ Grade was empirically measured on a numerical scale with the larger values representing the poorer grades.

cided influence upon the average grade into storage, as well as upon the loss in quality during the storage period. The average grade into storage of eggs which were held 3 days at 65° F. was 1.08 as compared to 1.27 for eggs which were held 7 days, 2.09 for eggs which were held 14 days, and 2.71 for eggs which were held 21 days. The average out-of-storage grade of these eggs was 2.24, 3.75, and 3.92, respectively. Temperature of holding eggs before storing also showed a marked influence upon egg quality. The average grade into storage of eggs which were held 14 days at 55° was 1.72 as compared to 2.09 for eggs which were held the same period at 65°. The average grade out of storage of these eggs was 2.80 for the eggs which were held at 55° and 3.77 for the eggs which were held at 65°.

Incubation of eggs.—In studies of the artificial incubation of eggs of domesticated birds, the New York (Cornell) Station found that the lowering of the temperature from 1° to 1.5° C. during the latter part of incubation of chickens' eggs gives a greater safety margin in obtaining a good hatch. This was proved by the high percentage of hatchability of eggs, the normal time and distribution of hatch, the heavy weight of chicks relative to the original weight of eggs, the small number of crippled chicks, and, at the time of hatching, the presence of a smaller amount of unabsorbed yolk relative to the weight of the chick. The early postnatal development indicated that the birds were of apparently normal health, as shown by gain in weight of some of the vital organs.

Crooked breastbone in fowls.—Crosses between strain of fowls with crooked and straight keel bones at the Kansas Station showed that although this condition was inherited, its expression was materially influenced by the sharpness of the roosts which the birds used during the growing period. If no roosts were used during the development of the crooked-keel-bone strain, practically none of the fowls showed the crooked characteristic. (See also p. 97.)

Improving laying turkeys.—By selective breeding and the use of artificial lights, the Oklahoma Station has developed turkeys that will lay the year round. The highest production so far obtained by the station is 205 eggs per year, with a pen average of 124.8 eggs each for 14 Bronze turkey pullets.

Vegetable proteins in turkey rations.—The Pennsylvania Station found that from 13 weeks of age to maturity satisfactory growth of turkeys was obtained when one-third or two-thirds of the total animal protein in the ration was replaced with an equal amount of vegetable protein, if calcium and phosphorus were added. Corn gluten meal produced a superior fleshing condition.

Cost of producing turkey eggs.—The cost of producing turkey eggs for hatching on farms was found by the Oregon Station to vary from less than 10 cents to nearly 30 cents. Only 40 percent of the farms had costs under 15 cents per hatching egg, but these farms produced 55 percent of the eggs. The average feeding and labor requirements, including feeding and care of the toms, were 56.5 pounds of mash, 52.2 pounds of grain, and 4.1 hours of labor per hen.

Castration in turkeys.—The plumage characteristic of castrated male and female turkeys was compared with normal birds of the two sexes in studies at the Kansas Station to gain insight into the role of the testes and ovaries in determining secondary sexual characters. The

study showed that castrated birds of both sexes resembled the male in plumage pattern at 16 weeks of age. Castrated females, as well as castrated males, were observed to express the normal strutting characteristic similar to normal males, but capons seldom gobble.

Poultry-farm management.—In a study of business factors responsible for success or failure in commercial poultry farming, based on records of 164 flocks in 1931 and 213 flocks in 1932, the Virginia Station found the controlling factors to be size of flock, quality of birds, diversity of business, labor efficiency, the early hatching of chicks, feeding efficiency, and low overhead investment. Profits and labor income were found to be directly proportional to the size of the flock. Apparently a flock of about 800 birds or more is necessary to insure efficient use of labor and equipment even on a general farm. Poultrymen who diversified their business by the sale of pullets and day-old chicks and who did custom hatching in addition to selling market eggs and broilers produced eggs at a lower cost per dozen and made higher average labor incomes than those who specialized in the sale of market eggs and broilers. Pullets which were hatched in March and April generally came into fall production at the time when the ratio between egg prices and the cost of feed was most favorable. The year-around feeding of mash containing some milk along with some green feed was found to be an important factor affecting the cost of producing a dozen eggs.

FISH AND OYSTER CULTURE

A wire tray for use in oyster culture.—A new type of all-metal wire mesh tray has been developed by the New Jersey Station for the saving and raising of natural oysters on the Cape May shore of Delaware Bay. A new type of support has likewise been developed and the whole gives a low-cost, durable, practical outfit for growing oysters. This new method of producing oysters has attracted considerable attention, and the indications are that it will be rather generally adopted in the very near future. It not only eliminates the pollution problem but at the same time materially reduces the time necessary to bring oysters to maturity.

Trapping oyster drills.—Effective means of trapping the oyster drill, a small marine snail which bores holes in the shells of young oysters and kills them, have been devised by the New Jersey Station cooperating with the Bureau of Fisheries. It is stated that the drill is responsible for more than a million dollars' worth of damages to the oyster industry in Delaware Bay every year. The use of a wire bag trap baited with young seed oysters has been shown to be a practical method of combating the drill under certain circumstances.

Fertilizing fish food plants.—The Wisconsin Alumni Research Foundation, cooperating with the United States Bureau of Fisheries and the State Conservation Department, is making fertilizer experiments on Weber Lake in that State to determine to what extent fish food may be profitably increased by this means. There was no pronounced response to use of superphosphate and lime, but addition of ammonium sulphate increased the fish-food content of the lake 22 percent.

H. W. MARSTON.
GEORGE HAINES.

ANIMAL DISEASES AND DISORDERS

The study of diseases and disorders of farm livestock is a leading feature of the work of the experiment stations as well as the Department of Agriculture and has contributed greatly to the efficiency and economy of farm production and to the quality and wholesomeness of food products supplied to consumers, thus aiding the producer and safeguarding public health. A few examples of recent work of the stations on animal diseases and disorders follow:

HORSES

Brain fever of horses.—Studies of brain fever of horses, commonly known as “infectious encephalomyelitis”, and the care of affected animals have been reported upon by the Utah Station. That station found the disease to be transmitted from affected to healthy guinea pigs by the mosquitoes *Aedes dorsalis* and *A. nigromaculis*, a fact of importance in the prevention and control of this deadly disease of horses. Further work by the Nevada Station indicates that the differences between the eastern and western types of the causative virus may in fact be only different degrees of virulence rather than immunological dissimilarity.

Iodine for goiter and navel ill in foals.—Iodine fed to pregnant mares was found by the Minnesota Station to prevent goiter and navel ill in foals in goitrous areas. The recommended dosage is 1 gram of potassium iodide each week in the grain feed during the last 7 months of gestation, or 1 ounce of potassium iodide in 1 gallon of water, using 2 ounces of the solution daily in the grain.

CATTLE

Mastitis.—Extensive studies of mastitis led the New York State Station to outline procedures by which the dairy farmer can aid in controlling the disorder as follows: (1) Test each quarter of every cow in the herd for infection either with the strip-cup or with the bromothymol blue test. (2) Segregate and milk last all cows reacting to either of these tests as well as animals giving watery or thick milk. (3) Test all replacements in the herd with bromothymol blue before adding them to the herd. If the animal is dry, seek the advice of a competent veterinarian. (4) Milk all cows dry at each milking. (5) Watch cows with injured quarters for infection. (6) Use reasonable sanitary precautions in handling the herd, particularly in disposing of the milk from infected animals. (7) If trouble still persists after following the above procedure, consult a milk-inspection laboratory or a competent veterinarian.

Success in diagnosing mastitis in the field through physical examination and the strip-cup and bromocresol purple tests is reported by the Virginia Station.

Further observations on mastitis and damage caused by it led the Wisconsin Station to conclude that approximately one-third of all the dairy cows in the State have chronic mastitis in some degree and that about 50 percent of their quarters are secreting abnormal milk. The station has urged dairymen to keep their herds as free

as possible from the disease by testing and removing reacting cows. It has been found that the nutritive value of milk and its value for cheese making are strikingly reduced by the infection besides creating a menace to human health. The several types of mastitis streptococci were found by the Michigan Station to manifest similar resistance to the devitalizing factors to which they were subjected, having remained viable in soil for 10 days and in tap water for 65 days. A study of the effect of mastitis on the quality and composition of milk led the Nebraska Station to conclude that mastitis, even when sufficiently mild so that the milk is still normal to casual observation, usually causes a significant decrease in the curd strength and an increase in the rennet-coagulation time of the milk.

Plans for the control of mastitis by the use of periodic laboratory examinations, segregation of animals, and general sanitation were described by the Connecticut (Storrs) Station. The use of a lactovaccine was found by the Michigan Station to greatly reduce the spread of mastitis infection, and in many cases protected all of the noninfected cows from the infection present in the herd. It appears to be best applied in a series of three weekly injections to the noninfected cows and to increase their resistance to the infection present in the herd. Where the eradication program is to extend over a period of years, it is recommended that the noninfected animals be vaccinated at least once a year. The importance of eliminating infected cows as soon as possible to decrease sources of the infective organism of mastitis was emphasized.

Bang's disease or infectious abortion (brucellosis).—In an attempt to simplify the problem of abortion disease control on the range, the Montana Station has developed a whole-blood agglutination test which can be used in the field and will eliminate the necessity of individual identification and a second handling of the cattle. The test is completed while the cattle are still in the bleeding chute, and the reactors can be marked and cut out immediately. By taking advantage of the possibility of testing by this method, many range herds can be given an annual test at shipping time in the fall, when all reactors may be culled out and disposed of immediately.

In examinations of English sparrows captured either in or around hog lots or nearby, within easy flying distance for such birds, they were found by the Michigan Station to be free from infection. It is considered possible that, in infected surroundings, the sparrows might carry infectious material on their beaks, feet, or in the alimentary tract, and thus spread the disease.

The herd of the National Bison Range showed a high percentage of reactors to abortion tests made by the Montana Station.

Johne's disease of cattle.—Johne's disease of cattle (paratuberculosis) is, the Illinois Station points out, a chronic, infectious, bacterial dysentery principally affecting cattle but also occurring in sheep, goats, deer, and occasionally in buffalo and horses. The station finds that cattle can be protected against the disease by—

enlisting the cooperation of the local veterinarian in the diagnosis of the disease, promptly eliminating reactors from the herd, practicing strict sanitation in stables, keeping pastures, feed, and drinking water clean, and adding to the herd only breeding animals that give a negative paratuberculin test.

Instructions for carrying out these protective measures have been published by the station.

Liver flukes in Puerto Rican dairy cows.—A large percentage of the dairy cows of Puerto Rico are infested with the liver fluke *Fasciola hepatica*, the Puerto Rico Station finds. The fluke is especially common in herds pastured or fed on malojillo grass because the wet conditions favorable to this grass are also especially favorable to the snail, which is the intermediate host of the fluke.

Nutritional blindness in cattle.—The Michigan Station has observed cases of constriction of the optic nerve, causing blindness in cattle. No positive evidence was obtained by the station that rations low in calcium and vitamins A and D are directly responsible for this type of blindness. Calves fed liberal amounts of vitamin A in form of "caritol" developed blindness. Feeding of corn silage, timothy hay, and cod-liver oil apparently prevented this type of blindness.

Rickets in dairy cows.—Rate of growth was found by the Michigan Station to be an important factor in the development of rickets in calves. More severe rickets was associated with more rapid growth. Younger cows developed more florid rickets than did older calves under similar circumstances.

Tetany in calves on milk rations.—Tetany was observed by the Michigan Station in calves fed whole milk or milk with different supplements and is attributed to magnesium deficiency in the ration. The station's attempts to raise calves to maturity on whole milk alone have consistently failed. Tetany was one of the outstanding abnormalities in such cases. A study of some of the blood constituents showed a marked lowering of the concentration of magnesium, coincident with extreme irritability or tetany. Low magnesium tetany did not occur when calves were fed ordinary normal rations because in this case the animals were able to utilize magnesium more efficiently from the roughage of the rations.

Fluorine poisoning of dairy cows.—Studies at the Wisconsin Station extending over a number of years have shown that fluorine, even in very small amounts, is exceedingly poisonous to animals when fed over long periods of time, and that materials containing appreciable quantities of fluorine cannot be used as animal feeds without harmful results.

SHEEP AND GOATS

Sore mouth of sheep and goats.—A serum method of vaccination which appears to be highly effective in the prevention of sore mouth of sheep and goats has been developed by the Texas Station. During the years 1933 and 1934 more than 2,500,000 lambs were vaccinated with excellent results. The immunity conferred by the vaccine appears to endure for at least 28 months, the method being practical, economical, and dependable. Field reports have corroborated the results of the station's experiments.

Pregnancy disease (acidosis) of ewes.—The Kentucky Station, which has for some years been making a study of acidosis, the so-called pregnancy disease in sheep, in a recent bulletin sums up the results of this study and makes practical suggestions for its control. It concludes that the trouble, which is the cause of severe losses during the last months of pregnancy, is clearly a condition resulting from improper nourishment and care of ewes and increased demand on the maternal calcium during the last 2 months of pregnancy. Advanced cases of acidosis of pregnant ewes appear hopeless, but the

condition can be prevented by proper nourishment and care of ewes during pregnancy.

Lungworms in sheep.—From a study of means of protecting lambs from lungworms, the Oregon Station recommends “(1) that lambs be watched closely enough to detect the first effects of these parasites, namely, loss of weight and bloom, and (2) that lambs be furnished better and more liberal feed.”

Copper sulphate for parasites of sheep.—The control of gastrointestinal parasites is one of the major problems of sheep raisers in the United States; drenching with copper sulphate solution is the common method for treating this trouble. The West Virginia Station found, in an effort to determine the best method of applying this treatment, that withholding of food for 24 hours before drenching increased its efficiency. A regular and systematic treatment of sheep with a 1½-percent solution of copper sulphate at intervals of 21 days was found to be an effective means of reducing intestinal infection. No ill effects resulted from this treatment. Proper feeding was shown to be an essential factor in successful treatment.

Chronic copper poisoning in sheep.—The so-called icterohemoglobinuria occurring on numerous ranches in the western part of the State was found by the Texas Station to be in reality a chronic copper poisoning. Analysis of commercial feed mixtures used on ranches where the disease occurred showed the presence of powdered copper sulphate in amounts varying from 5.3 to 9.9 percent.

Plants poisonous to sheep.—Two plants, *Psilostrophe tagetinae* and *P. gnaphalodes*, were added by the Texas Station during the year to those already known to be poisonous to sheep. The station found that—

Poisoning resulting from eating these plants manifests itself in general malaise, weakness in the legs as evidenced by stumbling when running, regurgitation of food as indicated by a greenish staining of the lips, and finally death. No remedy is known. Losses can be prevented by changing the animals to pastures not infested by these plants.

Symptoms of poisoning do not appear until about 3 weeks after sheep begin to eat the plants. Old plants (in the blooming stage) were found to be less toxic than younger plants.

SWINE

Bang's disease or infectious abortion (brucellosis).—Infectious abortion due to *Brucella suis*, as pointed out by the Illinois Station, is a widespread and harmful infection of swine, closely related to brucellosis in cattle, due to *B. bovis*, and a source of undulant fever in man. As protective measures against the disease that station recommends that—

all newly purchased breeding stock, even though apparently healthy and from nonaborting herds, should be quarantined until a negative blood test is obtained. Carriers of the disease, as well as animals actively infected, can be eliminated in this way. The spread of the disease through public and private sales can be prevented or greatly reduced by applying the agglutination test to all animals purchased at sales and withholding positive reactors from the herd. All newly purchased bred sows should be kept in quarantine until after they farrow and prove negative to two agglutination tests for brucellosis. Non-breeding sows should also be isolated until at least two negative tests at 30- to 60-day intervals prove that they are free from the disease.

Sanitary precautions, such as isolation of reacting animals and disinfection of houses and pens, should be rigidly observed.

It has not been established that swine can contract brucellosis from infected cattle, but it is known that cattle can be infected with *B. suis*. Every possible safeguard should therefore be employed to prevent the disease from being passed from swine to cattle.

Anemia in pigs.—The Oklahoma Station has found it possible to control to a considerable extent anemia of pigs during the first 2 weeks of their life by supplying them with fresh, clean soil or soil treated with copper sulphate and iron sulphate. The soil is placed in the corner of the farrowing pen at the time the pigs are farrowed. The Minnesota Station found that when suckling pigs were given an opportunity to ingest soil early in life they did not suffer from anemia. This is attributed to the fact that in this case the pigs did not suffer from a deficiency of iron in their diet. When iron was administered to the pigs in amounts equal to 4 or 5 milligrams per kilogram of body weight they did not develop anemia. It is suggested that other mineral elements of the soil may have had a part in preventing anemia.

POULTRY

Nutritional deficiency diseases of poultry.—As the Maine Station points out, "deficiency diseases, especially those caused by the lack of vitamins or minerals, have come to be recognized as universal problems of both animal and human nutrition." Striking examples of such troubles are rickets, due to vitamin D deficiency, and goiter, due to deficiency of iodine. Considering the question of nutritional deficiency diseases of poultry with reference particularly to use of Maine fishery products as possible correctives of certain of the troubles and the processing of the products with this purpose in view, the Maine Station says:

Maine white fish, herring, and sardine meal were found, by tests on chicks, to contain vitamin D—the factor which stimulates growth, deposits bone ash and bone fat, and decreases the amount of food energy required for growth. * * * Rapid fire-dried sardine meal contained vitamin D at a protective level when fresh. Eight months' storage reduced the potency extremely. On the other hand, vacuum-dried sardine, herring, and white fish meal retained vitamin D potency after 1 or 2 years' storage. Of the * * * vacuum-dried sardine meal [tested] the sample containing the highest percentage of fat (16.82 percent of ether and alcohol extract) was the most potent in vitamin D.

The station also found evidence that the Maine fishery products not only contain vitamins A, D, and G for the prevention of infections, rickets, and pellagra but essential mineral constituents, such as iodine necessary for relief of goiter, big neck, and hairlessness; iron and copper for prevention of nutritional anemia; calcium and phosphorus for bone growth, muscular development, milk secretion, and reproduction; and various others in less amounts, but that only through proper processing may these factors be preserved in the final product.

Paralysis in poultry.—This disease, which has become one of the most serious of those affecting chickens, has been studied by many experiment stations and other investigators. As yet, no specific treatment has been found for it. The South Carolina Station recom-

mends the following sanitary precautions as a means of controlling the disease:

Brood chicks on ground where chickens have not ranged for several years, and keep the growing pullets on a clean range until they are 5 months old. Disinfect the brooder house thoroughly before putting the chicks in it, and clean the house at least once a week afterwards. Keep the feeding and watering utensils clean. Keep a pan of creolin or some disinfectant at the entrance to the chick yard for disinfecting the soles of anyone's shoes before entering. Scrub and disinfect the permanent laying house thoroughly before putting the pullets in it. Where range about the laying house is limited, plow and reseed it before allowing the pullets on it. Purchase eggs, chicks, or breeding stock, if possible, from flocks which are known to be free of paralysis, as there are some indications that the disease is transmitted through the egg to the chick.

Breeding fowls for resistance to disease.—The Illinois Station has found in an experiment extending over a period of 10 years that heredity is an important factor in resistance and susceptibility to infection with pullorum disease, commonly known as bacillary white diarrhea. The Pennsylvania Station has bred strains of White Leghorn hens which show distinctly increased resistance to range paralysis and other diseases. Eighty percent of the granddaughters of bird K-1338 which were hatched in 1933 have lived, as compared with the flock average of 68 percent.

Vaccination for fowl pox.—A measurable degree of immunity against fowl pox has been obtained by the Illinois Station through the use of potent fowl pox and pigeon pox vaccines.

Fowl pox vaccine produces a stronger immunity than pigeon pox vaccine, but may be accompanied by a systemic reaction and may temporarily lower egg production. Pigeon pox vaccine, though it gives only a modified protection, may be used with less risk than fowl pox vaccine. It is important that fowls to be vaccinated be in a vigorous condition and free from other disease. Flocks that have never suffered from fowl pox or appear unlikely to contract it should not be vaccinated.

The station recommends that—

Pullets on infected premises should be vaccinated before they begin to lay. Reaction to fowl pox vaccination may check egg production in laying fowls. Fowl pox vaccination should therefore be avoided except in an emergency to check the spread of the malady. Pigeon pox vaccine can be used even in a badly infected flock without decreasing egg production and without danger of further spreading the disease.

Eradication of pullorum disease.—A recent report of the Massachusetts Station shows that as a result of systematic testing and elimination of fowls infected with pullorum disease, great progress has been made in eradication of the disease in that State as revealed by the fact that the average percentage of positive tests in 1934-35 was the lowest attained during the 15-year period of testing. Of the large number of birds tested only 0.39 percent showed evidence of the disease.

Avian tuberculosis.—According to the North Dakota Station, "avian tuberculosis is primarily a disease of the digestive tract in fowls" and is spread through droppings not only among fowls but to other animals, including cattle, sheep, pigs, pigeons, sparrows, rats, and mice. Pigeons and sparrows also spread the disease mechanically. Rats and mice are extremely resistant to the disease. Swine appeared to be particularly susceptible to infection.

Avian tuberculosis is an environmental disease wherein we are confronted with an overpopulation and a concentration of a volume of infection in the soil in a limited area on many farms. No success was secured in controlling

the disease merely by applying the tuberculin test and eliminating the reacting birds. The nominal value of individual birds permits an eradication procedure by slaughter. The rearing of the young birds in a sanitary environment on clean ground, and the regular disposition in the fall of all the fowls more than 1 year old, is an ideal program for the control of the disease.

The avian tubercle bacillus survives unusually well in nature outside the body of the fowl. It remained viable at a depth of 3 feet for at least 27 months after burial of infected carcasses. The tubercle bacillus was still viable and pathogenic in the litter and soil of the experimental cage barnyard after practically 4 years. Tuberculosis in fowls, as in animals, is ordinarily a slowly progressive disease, yet young chicks were found quite susceptible.

Vaccination for infectious laryngotracheitis.—Preventive work with this disease by the California Station has led to an improved method for vaccinating against it. The results obtained indicate that chickens cease to be virus carriers in about 1 week after vaccination against the disease. The Massachusetts Station found that the mortality from the disease was considerably increased when complicated by one or more species of bacteria that were recognized and described.

Work with a respiratory disease of chicks clinically similar to infectious laryngotracheitis which has occurred in various parts of the country has been carried on, particularly at the Rhode Island, Massachusetts, New Jersey, Kansas, and California Stations. The causative agent has been shown to be a filtrable virus, apparently different from the virus causing infectious laryngotracheitis, since birds immune to one contract the other.

Influence of environment on poultry diseases.—For a number of years the Nebraska Station has been attempting to measure the influence of practicable hygienic measures in poultry yards on the development of certain diseases. From the data accumulated the station concludes that the more sanitary environment, which included a graveled yard, hardware-cloth cover for the floor of the shelter house, and feeding and drinking equipment that prevented nearly all contamination of the feed and water, did not effectively reduce the spread of bacillary white diarrhea, tuberculosis, or fowl cholera, but it did aid materially in the control of blackhead of turkeys, coccidiosis, and fowl typhus.

Fowl resistance to ascarids (nematodes).—In experiments reported by the Kansas Station, the resistance of chickens to growth of the intestinal nematode *Ascaridia lineata* increased from the age of 45 days up to 93 days at which time the greatest resistance ordinarily was reached. It appears that as a chicken grows older its body develops more growth-inhibiting factors which react against the development of the nematode. The station has obtained evidence that chickens of different breeds and varieties vary in their resistance to the nematodes.

Most resistant to the parasites were the heavy breeds and varieties: Rhode Island Reds, White Plymouth Rocks, and Barred Plymouth Rocks; the most susceptible were the White Leghorns, Buff Orpingtons, and White Minorcas. A strain of heavy White Minorcas proved to be more resistant to the *A. lineata* than a lighter strain of the same breed with different genetic constitution. Factors in the differences in resistance appear to include greater utilization of nervous energy by the most susceptible breed, possible differences in strains within a breed, and the normality or tolerance of the host breeds.

The station obtained no evidence that the turkey is the natural host of the nematode nor that the chicken is an abnormal host. The

White Leghorn chicken at 2 months of age appeared to be a greater factor in the spread of the parasite than was the Bronze turkey of the same age. The station found that administration of carbon tetrachloride in a dose of 4 cc per kilogram of body weight was 100-percent effective in young chickens, and practically free from toxic effects. The egg production of pullets was, however, materially reduced for a period of from 7 to 10 days following the treatment.

Fowl flukes.—The Minnesota Station finds the oviduct fluke *Prosthogonimus macrorchis* in fowls to be a major factor in the decrease and in many cases almost complete cessation of egg laying by hens. Fowls having access to lake shores during the early summer were found to be most subject to infestation transmitted by dragonflies which emerge from the water in great numbers at that season.

Blackhead of turkeys.—From further studies of blackhead of turkeys and review of work of other investigators on the subject, the Rhode Island Station concludes that drugs and chemicals are of no value in prevention or treatment of the disease, and that occluding the ceca by use of clamps, if the turkeys survive the operation, gives only partial protection, but that the sanitary methods now generally used by Rhode Island turkey growers are quite satisfactory in controlling blackhead infection.

A comparison of the feed consumption and the mortality from blackhead of the turkeys reared on range and in confinement showed the range group to consume an average of 58 pounds of feed as compared with 58.66 pounds for the confinement group over a 25-week period. The range group of turkeys averaged 12.37 pounds in weight as against 13.32 pounds for the confinement group over the same period of time. The feed cost for the confinement group was slightly greater than for the range group. Four turkeys from the range group contracted blackhead as against one for the confinement group during the course of the experiment.

Good results in control of blackhead of turkeys were obtained by the Kansas Station by feeding continuously a mixture of 4 pounds of tobacco powder to each 100 pounds of mash from the time the poults are 4 weeks old until they are killed for market. The tobacco dust used contained 1.9 percent nicotine sulphate, and the poults were kept off the ground until they were 6 to 8 weeks old.

A disease of wild turkeys reared in captivity.—An epizootic among wild-turkey poults reared in captivity was found by the Missouri Station to be caused by a fungus developing readily in a commercial feed containing cod-liver oil and fish meal kept under damp conditions.

Plants poisonous to poultry.—The Florida Station has found seeds of *Glottidium vesicarium*, a native annual, to be fatally poisonous to poultry when administered in quantity. Naturally occurring cases of this poisoning have been observed. This station has also found the seed of *Crotalaria spectabilis* to be poisonous to the chicken, quail, turkey, and dove when eaten in considerable quantity. Under natural conditions the seed will be eaten by chickens, and sickness and death may be produced. Quail, however, did not eat the seed when placed before them or in the field. Turkeys were not poisoned by as many as a thousand seed. This plant is said to have been introduced into Florida by seed received at the station in 1921, since which time it has been grown in most parts of the State and in many other Southern States where it is used as a soil-building legume. Seeds of other species of the genus, including *C. striata*, *C. grantiana*,

C. incana, and *C. intermedia*, were not toxic when force-fed in 5- and 10-g doses to chickens and quail.

Crooked breastbones of turkeys.—The Wyoming Station has shown that the worst cases of crooked breastbones of turkeys are due to nutritional deficiencies. However, even when turkeys are fed on the best possible ration many of the birds develop dented breastbones and abrasions on the breast which render them low grade. A study of the effect of various types of roosts has produced practical results. Narrow roosts made of boards 1 inch thick set on edge produced bad dents. Use of a round roost (of lodgepole pine) 3 inches in diameter practically prevented the dents. The Nevada Station attributes crooked breastbones of turkeys to liberal use of protein feeds having a high mineral content. (See also p. 87.)

CATS

A disease of cats contracted from rodents.—For some years past the Kansas Station has received reports from livestock owners who have attempted to keep on their farms the required number of cats to hold down the rodent population, especially mice and rats, that they had met with failure because many of the cats contracted a contagious form of diarrhea resulting in the death of the cats. The station has isolated a specific virus and developed effective immunizing agents for the disease and is now in position to offer to farmers measures which will control the loss of cats from this disease.

GENERAL

Stock poisoning by selenium-containing range plants.—The discovery that the so-called alkali disease which occurs in certain areas in the northern Great Plains is due to selenium compounds absorbed by certain plants from soils derived from selenium-containing shales has led to further intensive research by several stations, particularly those of South Dakota and Wyoming, and by the Department of Agriculture (Bureau of Chemistry and Soils), especially with reference to absorption and accumulation of the poison in the plants. The Wyoming Station has found that certain range plants, particularly woody aster and plants of the genus *Oenopsis*, grow exclusively on and are indicators of selenium-bearing shale soils. Absorption of selenium by the plants apparently does not depend so much on the absolute amount of selenium in the soil as on the relative amount with reference to sulphur. In experiments with wheat plants there was normal growth with 1 part of selenium to 12 parts of sulphur. With a ratio of 1:8 growth was not normal. The injurious effect on livestock of eating plants containing selenium is not immediately evident but is accumulative and may be delayed for many months, the animals then becoming suddenly and seriously sick. The station finds that although selenium-poisoned animals may escape death they seldom recover full health.

As regards prevention and treatment of selenium poisoning, the Wyoming Station says:

Areas known to carry native vegetation containing harmful quantities of selenium should be properly marked to warn stockmen of impending danger to livestock. Consideration should be given to methods of controlled grazing in suspected areas during certain periods of the grazing season. Such pro-

visions will aid greatly in reducing livestock losses and the subsequent impairment of those animals not acutely affected at one time. * * * For acute poisoning, that is, cases where an animal has eaten a lethal amount at one feeding, there is no treatment that can be recommended. The delayed or blind stagger type of poisoning may be checked somewhat by drenching with warm water supplemented with the administration at intervals of strychnine sulphate. In well established chronic cases a full recovery cannot be expected. A few experimental cases have been kept under observation for a year and then autopsied. The initial injury in these cases was such that certain vital organs were irreparably damaged.

Poisonous principle in loco weed.—The poisonous principle in loco weed has been isolated and obtained in pure chemical form by the Texas Station. The name "locoine" has been given to the substance. The loco weed, which is widespread in the United States throughout the Rocky Mountain grazing region to the Mexican border, has been shown to be a serious hazard in livestock production. The isolation and identification of the poisonous principle which it contains may be of great aid in preventing or curing loco poisoning. The dried plant is as poisonous as the green, the horse being more susceptible to its poisonous effects than cattle, sheep, or goats. Feeding on the weed causes abortion in cattle. Adding concentrates to the ration increases the poisonous effect of the weed. Apparently the toxic principle is not excreted with the milk.

A cheap repellent for the buffalo gnat.—The Arkansas Station has developed a cold-mixed lubricating oil emulsion that is a cheap and effective repellent for the southern buffalo gnat, a pest which has from time to time caused large losses of livestock in the lower Mississippi Valley. It consists of potash-fish oil soap 1 pound, lubricating oil 3 quarts, and water 4 quarts.

Phosphorus deficiency in sugar-beet byproducts.—Unmistakable evidence of phosphorus deficiency in sugar-beet byproduct rations for livestock was shown in experiments reported by the Utah Station. This was shown by bone chewing, craving for salt, lack of appetite for normal feeds, soreness and swelling of the joints, and the low phosphorus content of the blood serum of animals fed the phosphorus-deficient rations. It was found that the deficiency might be remedied by adding cottonseed cake, mill-run bran, steamed bone meal, and barley to the ration. Steamed bonemeal proved to be the most efficient phosphorus supplement tested.

Effect of Fowler's solution on animals.—Fowler's solution has long been used in fitting animals for showing, in the belief that it aids in putting on fat and increasing the glossiness of the hair coat. The Illinois Station finds, however, that feeding of Fowler's solution to farm animals detracts from their value as breeders, increases mortality of the offspring, and probably results in general sluggishness.

WM. A. HOOKER.

FOODS AND NUTRITION AND HOUSEHOLD MANAGEMENT

There is much in common between the requirements for human nutrition and those for animal nutrition; in fact much that has been learned from small-animal research is applicable alike to human beings and farm animals. Household-engineering problems often overlap farm-engineering problems. Family economics is closely tied up with farm economics and home management with farm management.

A few examples have been selected from experiment station work underway or completed during the year to illustrate progress in the many fields of research contributing to the welfare of the family through newer knowledge concerning food composition, preparation, and utilization; food habits and nutritional requirements; textile analysis and clothing selection; household equipment and engineering; and various aspects of family economics.

FOOD PREPARATION

Food-preparation studies at the experiment stations cover several different types of work. There are, first, the routine cooking tests according to prescribed methods to prepare foods for quality judging. To this type belong the meat-cooking tests in connection with the cooperative meat investigations of the Department of Agriculture and various experiment stations and the potato-cooking tests which are carried on at a number of the stations in potato-growing regions as an aid to variety selection and cultural practices.

A second type of food-preparation study has for its purpose the development of improved methods of cooking foods which are, or give promise of being, important agricultural crops in the State, such as pinto beans in New Mexico and soybeans in Illinois, or the utilization of surplus byproducts such as lard.

Finally, there is fundamental research on the principles involved in various cooking processes, undertaken in the hope of replacing trial-and-error methods with definite foolproof rules applicable under varying conditions. Such research may require repeated tests with the alteration of one factor at a time or even exhaustive studies of the chemical nature of various food constituents, such as starch or fats.

A few examples have been selected to illustrate recent progress in this varied field.

The cooking qualities of potatoes.—Perhaps the most sought-for quality in a potato is mealiness. The property of cooking to a satisfactory state of doneness without sloughing because the outside cooks more quickly than the inside is another important quality. These qualities have been found to depend not only on variety and method of storage but also on soil conditions. Recent studies at the Maine and Ohio Stations have shown that potash fertilization tends to increase the mealiness of potatoes. In the Maine studies the most mealy potatoes were obtained from plats receiving potash in the form of potassium sulphate, while the least mealy were from a plat fertilized with a mixture containing nitrogen and phosphorus but no potassium. The Ohio Station also noted that the potash-fertilized potatoes were of particularly good flavor. Potatoes grown on irrigated soil were found by the Wyoming Station to cook more evenly than dry-land potatoes of the same variety. In an attempt to determine the cause of this unevenness in cooking, the Wyoming workers cut thin slices of the potatoes and photographed them under the microscope. These microphotographs showed marked differences in the cellular structure of the dry-land and irrigated potatoes, the former having much larger cells near the outside than in the center. If cell size should prove in further study to be an indication of the

cooking quality of potatoes, some of the guess work in judging quality might be eliminated.

Cooking pinto beans.—The pinto bean is a characteristic and staple article of diet in the southwest United States. The Arizona and New Mexico Stations have succeeded in improving the quality of the bean in various ways. The New Mexico Station has also studied the culinary quality of the bean and the best methods of preparing it for the table. The station finds that the character of the water used has much to do with the quality of the cooked bean, and has worked out in some detail the process which it considers best to follow in cooking beans in hard and soft water. The hardness of the water seems to be the greatest factor in the cooking of a palatable bean, and the harder the water the more difficult the cooking process becomes. The station recommends that hard water be boiled before using and only enough of it be used to cover the beans. It also recommends the use of a kettle with a close-fitting cover to prevent evaporation, soaking in hot water, and use of soda ($1\frac{1}{2}$ teaspoons to 2 cups (1 pint) of beans) to soften the skins and shorten the time of cooking.

Soybeans a promising food.—Several of the experiment stations are cooperating with the Department of Agriculture in growing promising varieties of soybeans and testing their cooking properties, either as a fresh green bean or after drying. In such studies at the Illinois Station it was found that great variety in shape and color can be had in soybeans of satisfactory flavor and cooking quality. Some resembled lima beans in size and texture, others were red brown like kidney beans. Two varieties which proved very palatable as a green vegetable were tan or ivory in color. All of the beans tested in the dry state cooked tender in about $1\frac{1}{2}$ hours, even when not soaked beforehand.

Cake baking.—The use of Illinois soft-wheat flours in baking is the subject of continued study at the Illinois Station, where it has been found that the soft-wheat flours with suitable milling can be used in place of hard-wheat flours for bread as well as for cake, while hard-wheat flours do not as a rule make very satisfactory cake. In a further comparison of hard- and soft-wheat flours for cake baking both types were used in cake formulas of four grades of richness (proportions of fat, sugar, and eggs). The hard-wheat flours did not give good results with the most rich and the least rich formulas. The cakes were baked with thermometers inserted in the cake mixture and it was found that the temperature in the least rich cake rose very slowly and did not go over 100° F. The cake, although it appeared done, tasted of undercooked starch.

Several years ago satisfactory recipes were developed at the Colorado Station for baking cakes at different altitudes. This was done by trying out various proportions of the different ingredients and baking the cakes in the unique altitude laboratory. More fundamental research at the station on the effects of changes in altitude on the proportions of the various ingredients required for making a satisfactory angel food cake has shown that the tenderness of the cake increases with the altitude and the sugar content of the cake and decreases with increasing amounts of flour and egg white (the other ingredients in the cake). Too tender a cake will fall; consequently, with a given amount of flour and egg white the sugar

content must be decreased with increase in altitude. In fact a point is reached at an altitude above 10,000 feet where a cake of satisfactory texture will contain no sugar. Under such circumstances a thick icing is desirable. A mathematical equation has been developed for calculating the amount of the different ingredients to use at any altitude, but for the homemakers who do not care for algebra, tables have been prepared giving the amount of sugar for several different amounts of flour and egg white (depending upon the size of cake desired) at various altitudes from sea level to 15,000 feet.

Starch in cooking.—Starch is one of the ingredients which plays an important part in the quality of many cooked foods, not only those containing flour mixtures but others in which starch is used as a thickening agent. On the theory that staleness in breads, cake, and other cooked flour mixtures is probably due to changes in starch, the Illinois Station is devoting considerable attention to physicochemical studies of starches. Recently a new method of making starch from corn has been developed yielding a product which sets to a gel at lower temperatures than commercial starch, thickening in solutions at 70° C. instead of 80° and forming a definite gel at 85° instead of 90°. A saving in time and heat in various cooking processes through improvements in the manufacture of starch is suggested as one of the practical benefits which may come from this research.

FOOD PRESERVATION

Many problems arising in connection with the preservation of foods in various ways receive attention at the experiment stations with resulting benefit to the homemaker. In addition new ways of preserving foods and of preparing such products as sirups, vinegar, etc., on the farm are continually being developed.

Storage of corn meal.—The New York State Station has found that corn meal stored under ordinary conditions and subjected to excessive heat during the summer underwent considerable deterioration, especially loss of fat. If kept at a temperature of 65° F. or below, there was practically no change in the fat content even with a moisture content of 14 percent or more. If the moisture content was kept below 8 percent, the temperature of the storage could be raised to 98° without any apparent effect on the fat content. It would seem advisable to store the meal in the ice box, or, if this is impracticable, to dry it out pretty thoroughly and keep it in closed containers.

Care of meat in the home refrigerator.—Results of tests by the Iowa Station show that refrigeration is desirable for ham and bacon, for although these meats are cured and do not spoil as rapidly as fresh meats, nevertheless in a moist atmosphere mold forms rapidly and tends to give the meat an undesirable flavor. They may be kept at 50° F. or below. Shrinkage is least when cured meats are kept in covered containers, moderate in amount when the meats are wrapped, and greatest when stored uncovered. The unwrapped meats keep longer but with long holding develop a salty or smoky flavor. Bulk sausage may be stored in paraffin paper, but sausage in casings should be removed from the carton and wrapped in parchment paper. Dried beef stored in paraffin paper or a covered container shows comparatively no shrinkage loss. Ready-to-serve meats spoil more readily than other classes of meat and should be

stored for as short a time and at as low a temperature as possible. If left unwrapped they tend to transmit their flavor to other foods.

Nutritive value of frozen vegetables.—Interest of consumers in the nutritive value of frozen fruits and vegetables is reflected in investigations undertaken by a number of experiment stations, including those of Georgia, New York, and other States. The Georgia Station has for some time been studying the quality of frozen fruits and vegetables from the standpoint of their home use and has suggested ways in which they may be made more acceptable to the housekeeper. The New York State Station, in view of the fact that the production of frozen fruits and vegetables is steadily increasing in that State, has undertaken a comprehensive study of the suitability of New York products for this method of preservation as well as of the nutritive value of the frozen products.

Microbiology of frozen foods.—The University of Illinois concluded from a study of the nature and activity of micro-organisms in frozen foods that as long as the food is kept in a frozen state micro-organisms have little effect on its quality. When, however, the temperature is raised to a suitable point for their growth they are able to cause spoilage. To maintain high quality the foods must be kept solidly frozen until used. They should not be kept in an ordinary refrigerator nor at room temperatures.

Home canning by safe methods.—The discovery by the Montana Station that there were many agencies in the State giving out conflicting canning directions to homemakers led to a conference at the station of representatives of these agencies. After full discussion of safe methods of canning, definite agreement was reached and the methods recommended were incorporated in a station circular. The directions given therein are simple and easily followed. With this circular in the hands of every homemaker in the State spoilage of canned foods should be at a minimum and the danger of botulism eliminated.

Jelly making.—It is discouraging to both the homemaker and the commercial jelly manufacturer who has been relying upon a standard recipe for a particular type of jelly to find that occasionally the recipe does not work. Pectin, sugar, and acid are the three ingredients which in proper proportions and concentrations make a satisfactory jelly. How to determine quickly the particular jelling quality of any fruit extract is a problem which has been receiving considerable attention at the Delaware Station with the discovery that the viscosity of the extract as determined by the length of time required for a definite amount of the liquid to flow through a fine tube is a measure of its jelling power. Up to a certain point the lower the viscosity, the better the jelly. If the viscosity is very low, it may be necessary to add a little pectin but, within certain limits, the addition of sugar alone will bring the viscosity up to the correct point. The instrument for determining the viscosity is a simple device, adaptable to use in the home or factory, known in the laboratory as a viscosity pipette and christened for jelly making under the name jelmeter. From the time in minutes required for the extracted fruit juice at room temperature to flow from the upper to the lower mark of the jelmeter the quantity of sugar to add to each pound of juice can be read from a table which also gives the end point of cooking in terms of the weight of jelly for each pound of juice.

Improving the quality of sauerkraut.—The quality of sauerkraut is known to depend on many factors which influence its fermentation, including temperature, amount of salt present, cleanness of the cabbage, and the method of covering the sauerkraut during the fermentation process. The New York State Station has worked out processes which take account of all these factors and insure the production of a sauerkraut of good quality and high nutritive value. The station says:

Sauerkraut should be sour with a pleasant typical aroma when fully cured and should have a firm crisp texture and a bright light straw color. This may not resemble the product to which some are accustomed, but it is the most wholesome product. Very often home-made kraut is darker in color and less crisp and firm than commercially prepared kraut and people accustomed to the home product regard firm, light-colored, acid commercial sauerkraut as uncured. It is important to know that the juice of kraut has practically the same food value as the solid part, and furthermore the juice is higher in vitamin content than the solids. The juice is quite often discarded in using kraut without appreciation of its food value.

Improved methods of making sirup.—The greater part of the cane and sorgo sirups used in certain sections of the country is made on the farm or in community mills. The Arkansas Station, cooperating with the Department of Agriculture, has made certain definite improvements in sirup-making methods. The use of malt with raw juice or semisirup, for example, has been shown to be effective in remedying the slow boiling of the juice in the making of the sirup and also in preventing the jellying or clabbering of the sirup upon standing. This will enable farmers to make usable and salable products in cases where they have failed heretofore. It will lead to standardization of the sorgo product in communities for larger home consumption and for marketing cooperatively.

VITAMINS IN PROCESSED FOODS

It is not always feasible or economical to use fresh raw fruits and vegetables to obtain the daily quota of vitamins. What reliance can be placed on food materials processed in different ways? Attention is being paid in experiment station research to the development and selection of processing methods for use either in the home or in commercial practice which shall best preserve the vitamin content of the natural foods, and to the examination of processed foods already on the market to determine how safe a substitute they are for the natural food.

Vitamins in dried fruits.—The preservation of vitamins in fruits during the commercial processes of drying has received considerable attention at the California Station over a number of years, during which studies have been made of the content of vitamins A, B, C, and G in various fruits sun-dried, dehydrated, sulphured, or non-sulphured. It was found that dehydration and sulphuring tend to protect vitamins A and C, which are easily destroyed in the oxygen of the air. Vitamin B, on the other hand, is destroyed to some extent by the heat of the dehydration process and by the sulphuring process which protects the other vitamins. Vitamin G, apparently, is not destroyed to any extent by either oxidation, reduction (sulphuring), or heat. The choice of methods for different fruits will then depend upon what vitamins are present in such amounts as to make it worth

while to try to prevent their destruction. According to the California workers—

Peaches and apricots should be dehydrated and sulphured to retain their excellent natural content of vitamins A and C, even though their small B content be largely lost. Raisins should not be sulphured, but should be lye-dipped and dehydrated to preserve their good vitamin B and A content, and should not be counted on for vitamin C. Prunes should be lye-dipped, not sulphured, and dehydrated also, since their natural endowment is similar to that of raisins. Figs, which are not rich in either A or C, should be unsulphured and either dehydrated or sun-dried. The black Mission figs, however, contain enough vitamin A to merit dehydration.

This practical advice for the producer is of some help to the consumer, for packaged dried-fruit products often contain information on the methods followed in drying. Among the common dried fruits, apricots and prunes appear to make about the best contribution of vitamins, apricots for vitamins A and C, and prunes for A, B, and G. According to the California studies, the vitamin G content of the dried flesh of the California (French) prunes is higher than has been reported for any other fruit, and about equal weight for weight with one of the best sources of vitamin G, wheat germ.

Vitamin C in tomato products.—Canned tomato juice is used very extensively as a convenient, inexpensive source of vitamin C for babies, children, and even grown-ups. What reliance can be placed on different brands for uniformity in vitamin C content? Several commercial brands and samples for 3 consecutive years of the same brand of tomato juice were examined for their vitamin C content by the Massachusetts Station with the conclusion that although there was considerable variation among the different brands, and the same brand in different years, all but one of the samples tested might be considered good sources of vitamin C. The brands judged best in color and flavor were consistently highest in vitamin C, but whether this would always hold true could not be predicted from the rather small number of samples tested. The protective doses for standard guinea pigs of the samples of commercially canned tomato juices tested ranged from 2 to 6 g daily. As orange juice is usually protective in doses of 1.5 g daily, this means that tomato juice is not quite as rich in vitamin C as orange juice, and when substituted for it as an antiscorbutic, a more generous allowance should be the rule in place of volume for volume as often recommended.

The chance substitution with less satisfactory results of a commercial tomato-juice cocktail for tomato juice in some guinea pig feeding tests at the University of Maine led to the discovery that the cocktail contained much less vitamin C than the brand of tomato juice used. In a further examination of the vitamin C potency of three commercial brands of tomato-juice cocktail, it was found that scurvy, from mild to severe, developed in all of the guinea pigs given 3 cc daily of the cocktails, while none of the animals receiving 3 cc of orange juice or a commercial brand of tomato juice showed any symptoms. The most discouraging feature of these findings is not that tomato-juice cocktails, which are presumably used more for their appetizing flavor than for their vitamin contribution, may be lower in vitamin C than the average commercial tomato juice, but that the labels of the two cocktails examined bore misleading vitamin claims, a fact which shows the urgent need of more accurate labeling.

Many rural homemakers are preserving part of their tomato crop as canned juice and puree as a change from the time-honored canned tomatoes. Some of the questions which have arisen about best methods to follow to preserve the vitamin C intact are answered by the observation in the Massachusetts study noted above that sieved juice canned in the laboratory compared favorably with the best commercially canned juice examined, and that a puree obtained by concentrating tomato juice to half its original volume by open-kettle boiling contained volume for volume about the same amount of the vitamin as in the original juice. In other words, a 50-percent loss in vitamin C accompanied a 50-percent concentration. Other home-canning questions have been answered in recent studies at the Wisconsin Station which have shown that home-canned tomato juice is richer in vitamin C if the tomatoes are sieved hot than cold, and that there is some loss of the vitamin when the juice is stored in bottles sealed with a cork and paraffin instead of being capped. Tomatoes canned 6 years ago were found to have only about one-fourth as much vitamin C as when tested 6 months after canning, an argument for a well-planned canning budget to avoid surpluses as well as to provide a sufficiency of canned goods for the winter months.

Vitamin B in wheat products.—The importance of vitamin B in nutrition, particularly in stimulating the appetite and maintaining the tone of the gastrointestinal tract, is being recognized to an increasing extent, as well as the necessity of special thought in providing an abundance of this vitamin in the diet. Wheat germ is one of the most practical sources of vitamin B, either as it occurs naturally in whole wheat or as separated from it and used alone, or as a reinforcement to wheat products. Studies at the University of California have given the following comparative vitamin B values for some of these wheat products: Whole wheat 170, the germ from the same sample of wheat 1,032, the same sample of wheat fortified by a 20-percent wheat germ (the breakfast cereal known as wheat hearts) 329, and a trade preparation of cereal germ 1,170 Sherman units per gram. With figures such as these it becomes an easy matter to make various selections or combinations of wheat products to furnish equivalent amounts of vitamin B.

As most of the wheat for human consumption is used in bread making, the California studies were extended to various types of bread made for the most part according to standard formulas suggested by the Association of Cereal Chemists. Whole wheat, rye, and white breads were found to contain from 40–53, 34, and 12 Sherman units respectively per ounce of fresh bread. The addition of 20 percent wheat germ nearly tripled the vitamin B content of the bread, but at the expense of volume, texture, and appearance. The incorporation in a white-flour bread of raisins to the extent of 65 percent of the weight of the flour increased the vitamin B value about one-fourth, but the usual skim-milk powder addition did not increase the vitamin B content of the bread. A comparison of the vitamin B content of the ingredients and the finished bread showed very little loss of the vitamins during baking at temperatures from 350° to 446° F. although there was slightly more loss in the 1-pound than the 1½-pound loaves, and in the crust than in the

crumb. As 1 ounce is equal to nearly 30 g, it will be seen that the use of certain whole-wheat cereals, or the use of a little wheat-germ concentrate, of which there are two or three on the market, is a more efficient way of providing vitamin B than depending upon breads for this vitamin.

Vitamins in frozen foods.—Large quantities of foodstuffs, particularly fruit and berries, are preserved each year by quick freezing. It has generally been assumed that this method of preservation does not result in any appreciable vitamin loss; in fact many vitamin studies are made on the frozen rather than fresh material on account of the difficulty in obtaining a continuous supply of the material during the long time required for biological tests. This was done with blackberries in recent studies at the Washington Station where it was found that the frozen blackberries from the 1932 and 1933 pack of the Puyallup and Sumner Fruit Growers Association were a relatively good though not outstanding source of vitamin A, and a relatively poor though not entirely deficient source of vitamin C.

The question of destruction of vitamins in milk by quick freezing was studied at the Georgia Station, with the conclusion that "milk frozen by the quick frozen method and tested after being stored for four months and two years respectively shows no significant lowering of vitamin A or vitamin G content over that found in fresh milk from the same source."

Detecting changes in vitamin C.—The development of a chemical test for vitamin C is now making possible studies of the effect of various factors, including different methods of processing, on the vitamin C content of foods. Such studies are under way at the Georgia Station on southern grown fruits and vegetables, at the New York State Station on vegetables, and at the Ohio Station on milk. The purpose of the Ohio study is to trace the vitamin C content of milk from the time it leaves the cow's udder until it is finally consumed in any form. If it should prove that perfectly fresh milk as drawn from the udder is a good source of vitamin C, it will be possible to show just where the losses begin and perhaps how they may be prevented.

Irradiated foods.—As the number of foods enriched with vitamin D by irradiation or by the addition of irradiated ergosterol increases, the question arises as to the possibility of getting too much of a good thing. Should a baby be given vitamin D milk, an irradiated cereal, and vitamin D bread, to say nothing of cod-liver oil and of eggs, which contain small amounts of vitamin D? To answer this question the Wisconsin Station fed rats for 10 months (a period equivalent to between 2 and 3 years in the life of a child) all that they could consume of various forms of vitamin D milk containing from 50 to 5,000 Steenbock units of vitamin D per quart, with not the slightest evidence of harm. These findings were thought to warrant the following statement:

When it is appreciated that at the higher levels these experimental rats were receiving as much as a hundred times more vitamin D than would be present in a normal ration or diet made up of irradiated foodstuffs, these experiments confirm previous opinion that there is little or no chance of injury with the consumption of irradiated milk.

TRACE ELEMENTS IN NUTRITION

The term "trace element", as applied to foods and nutrition, means those chemical elements which occur in foods or drinking water in very small amounts or traces, and are either beneficial or harmful to the body. The significance of these elements has only recently been recognized and knowledge concerning them is still incomplete. Some of the trace elements such as copper, manganese, and possibly zinc are essential to the body. Others like selenium and fluorine are harmful. The experiment stations are playing an important part in determining the significance of the trace elements in nutrition. The Arizona Station is associated with the discovery that the disfiguring condition of the teeth known as mottled enamel is caused by traces of fluorine in the drinking water; the Wisconsin Station with the solution of many of the problems concerned with the function of iron in the formation of hemoglobin, particularly the discovery of the part played by copper; the South Dakota Station with the problem of selenium as a toxic substance in grain and forage crops grown in certain localities. In each case the problems are complex and require years of patient effort for complete solution. Each year sees some new facts added through experiment station research to knowledge of trace elements. Some of the new information is chiefly of theoretical interest while other discoveries are of direct practical application.

Available iron (and copper) in food materials.—Strictly speaking, iron is not a trace element for it occurs in foods in easily measurable amounts and has long been known to be essential in nutrition. However, it was only with the discovery that the trace element copper is necessary for the proper functioning of iron in the body that new facts concerning iron came to light which have completely upset earlier ideas as to the form in which iron is available to the body.

It was noted in the 1934 report that the Wisconsin Station had found a marked difference in the effectiveness or availability of iron from different food sources. Rapid progress in testing foods for available iron has been made at the station, and elsewhere, since a certain chemical test for available iron had been found to check closely with the long tedious feeding tests for hemoglobin regeneration in anemic rats. Among a number of foods recently tested at the Wisconsin Station egg yolk headed the list with 100 percent of its iron content in available form. Strange to relate, the food at the bottom of the list with only 20 percent of its iron available was none other than spinach, so long held in high esteem as a food source of iron. Soybeans and navy beans proved to be far better sources with 80 and 60 percent of their iron in available form. Of course, the relative amounts of total iron must also be taken into consideration in thinking of the actual amount of iron available in any particular food.

Pondering upon the marked differences between total and available iron in many iron-rich foods, the Wisconsin investigators raised the question, "If milk is exceedingly low in iron and many of the foods used as supplements to milk in infant feeding have a low available iron content, can we rely on these foods to prevent anemia?" To answer this question, the Wisconsin studies were extended from the

laboratory to the child health centers in Madison, Wis., where determinations were made of the hemoglobin content of the blood of many infants and young children. Although severe anemia was seldom encountered, a very large percentage of supposedly well-fed children had some degree of anemia and responded so readily to iron and copper therapy as to indicate that their diets must have been on the border line of adequacy, and to lead the Wisconsin investigators to answer the above question as follows:

The maintenance of an optimum level of hemoglobin in rapidly growing infants by food alone is only possible if the demands on the iron and copper reserves in the liver are reduced to a minimum by the early inclusion of food rich in these elements. If an infant is born with a reduced supply or if the supply is depleted by illness or other cause, it is very difficult to reestablish a high level of hemoglobin with food alone. Our results suggest that it may be advisable to add small amounts of iron and copper to the diets of some infants to insure optimum hemoglobin formation.

In supplying additional iron and copper it should be remembered that these elements occur in small amounts only in the body and that iron and copper medication should be in correspondingly small doses. In fact the Wisconsin investigators have found in their experimental work with rats that fairly large amounts of iron interfere with the assimilation of another essential mineral element, phosphorus, to the extent that continued dosage may lead to rickets in the young animal. In order to avoid overdosage all of the sources of iron entering into the diet of infants and young children should be taken into consideration before medicinal iron is given. There has been some question as to the probability of copper deficiency. In the Wisconsin work with infants it was found that although there was some response to iron alone, in the majority of cases the response was much better when copper was given in addition.

Other experiment stations are also making contributions to knowledge of total and available iron content of foods of particular regional interest. The Mississippi Station is continuing its investigations of sorgo and sugarcane sirups as sources of iron and copper. The Georgia Station is studying the availability of iron in inexpensive locally grown foods such as collards and turnip tops. The New Mexico Station is working similarly on pinto beans.

Is zinc an indispensable trace element in nutrition?—Generally speaking, trace elements found essential to plant nutrition are also shown to be essential to animal nutrition (including man). This is true of iron and copper, and there is a strong probability that it is likewise true for zinc. It was recently demonstrated at the Arizona Station that a disease of the pecan tree known as pecan rosette, which occurs in areas in Arizona where the drainage waters have an extremely low zinc content, can be promptly cured by the administration of zinc salts. On the theory that in areas such as this zinc may also be a limiting factor in animal nutrition, the Wisconsin Station studied the effect of a low zinc diet on rats with the conclusion that zinc is an indispensable element for growth and the development of normal fur in rats. Although no experiments have been conducted on other animals than rats and mice, it was assumed that zinc is also an indispensable element for the nutrition of other animals, including man. How it functions is still unknown although it is considered significant that all attempts to free insulin from zinc have

resulted in failure in spite of the fact that iron and phosphorus, also present in the ash of insulin, can be removed without difficulty.

Fluorine as a harmful trace element.—In the earlier studies of mottled enamel at the Arizona Station, only the permanent teeth were found to be affected. Recently the Arizona investigators observed severe mottling of the enamel in all of the temporary teeth of children in a community in the State in which the fluorine content of the water was exceptionally high, from 12 to 16 parts per million. Mottled enamel of the permanent teeth was also noted in families in the same community who had not used the high fluorine water for drinking but only for cooking and other household purposes.

The way in which fluorine acts to produce such disfiguring changes in the teeth as mottled enamel and other harmful effects is being studied at several of the experiment stations (p. 19). At the Arizona Station rats fed fluorine in the relatively high concentration of 0.1 percent of sodium fluoride in the ration, retained less calcium and phosphorus and a relatively lower proportion of calcium to phosphorus than animals receiving no fluorine. This suggests that fluorine interferes with the absorption of calcium and phosphorus, particularly calcium. Sodium fluoride was also found to retard the rate of eruption of the incisor teeth and the rate of body growth but not to interfere with either digestion or retention of proteins.

Recent reports in the medical literature of the use of fluorides in the treatment of toxic goiter led the Wisconsin Station to test the effects of sodium fluoride and desiccated thyroid singly and combined on the basal metabolism of rats (an increased basal metabolism being one of the important signs of hyperthyroidism). The materials were fed in amounts which, when taken singly, had no appreciable effect on body weight, at least over short periods of time. The sodium fluoride and desiccated thyroid when administered together caused a rapid loss in body weight followed by collapse and death in from 2 to 3 weeks. The basal metabolism of the rats was not changed appreciably by sodium fluoride, was increased 35 percent in 3 weeks by the desiccated thyroid alone, and 65 percent within 1 week by the desiccated thyroid and sodium fluoride. Sodium fluoride would thus seem to be very harmful instead of beneficial in the treatment of the hyperthyroidism of toxic goiter. The possibility is also suggested that high fluorine drinking water may not only cause mottled enamel but also be one of the factors responsible for hyperthyroidism in susceptible persons.

INTERRELATIONSHIPS AMONG FOOD CONSTITUENTS

Attention has been called to the fact that not all the iron in certain foods is available to the body. This is also true to a greater or less extent of most food essentials. In some cases the utilization of a particular food constituent is increased by the presence of another which exerts what is known as a sparing effect. Fat, for instance, has a sparing effect on vitamin B. In other cases one constituent seems absolutely essential for the functioning of another, as copper for iron. Of two substances of similar nature such as sucrose or ordinary sugar and lactose or milk sugar one may be harmless and the other harmful when consumed in large amounts or under certain conditions. Increased knowledge of the interrelationships among

food essentials may help to solve some obscure nutritional problems as well as throw some light on conditions not hitherto connected with diet. A few examples from experiment station research in this field will serve to indicate how complex are the problems of nutrition and how great is the need for further research in this field.

Protein utilization.—The value of any food as a source of protein (building material) depends upon the quantity of protein in the food, its digestibility, and its biological value or the suitability of the end points of digestion (amino acids) for the needs of the body. All three of these items must be considered in determining the value of any food as a source of protein. Nuts are often recommended as meat substitutes without much thought of anything but their protein content in comparison with meat. The Illinois Station, after a study of various nuts from the standpoint of digestibility and utilization as well as protein content, came to this conclusion:

Peanuts, English walnuts, and pecans, the favorite nuts in the American diet, cannot be considered satisfactory meat substitutes from the standpoint of protein nutrition, even though they are often considered as such by dietitians. This is because of the large wastages that occur in the course of the utilization of their protein in the animal body, either in digestion or metabolism or in both. Furthermore, in the case of peanuts, at least, they exert only an inconsiderable effect as compared with meats in improving the utilization of white-flour proteins when fed in combination with them. The beef sandwich is thus a more valuable protein food than the peanut sandwich.

The data from which these conclusions were drawn were obtained in feeding experiments on rats. The same type of study can be carried on with human subjects although it is a long and tedious process. Three young women served as subjects in studies at the Kansas Station of the utilization of the nitrogen and phosphorus of various cuts of beef. Both the nitrogen and phosphorus of beef loin were utilized somewhat more completely than that of the heel of beef, indicating that when the cheaper beef is substituted for the more expensive loin in the diet, the amount should be increased slightly. The nitrogen of beef round was utilized practically as well as that of beef liver and of the beef heart slightly better than beef round. The beef heart showed a very slight superiority over beef round and liver as a source of phosphorus.

Lactose in nutrition.—One of the reasons why milk is so essential in infant feeding is that it is high in calcium, which is necessary for bone formation, and one reason why cod-liver oil is almost universally prescribed for infants and young children is because the vitamin D which it contains helps in the utilization of the calcium. It has recently been demonstrated at the Illinois Station that lactose, the form of sugar which is present in milk, also has a definite calcifying effect, but that other forms of carbohydrates such as starch or sucrose have no such effect. Occasionally children are sensitive to milk, or have an allergy for it as such sensitivity is usually described. Babies who are thus unable to drink milk must obtain their calcium from other sources and it is quite probable that they would be benefited by having their diet supplemented by lactose as well. Plans are being made at the station to test this point.

While an investigation at one of the stations is thus demonstrating the beneficial effects of lactose in moderate concentrations, at another station (Massachusetts) it is being shown that when lactose makes up a very large part of the diet of experimental rats, cataracts form

in the crystalline lens of the eye. As these cataracts are very similar to senile cataracts in human beings, their study may open the way to an understanding of the cause, and, it is to be hoped, the prevention of human cataracts. No cataracts developed in rats fed the same high proportion of other carbohydrates such as starch, maltose, dextrin, or sucrose, but galactose, a simple sugar formed by the break-down of lactose, caused cataracts to form approximately four times as quickly as did the same amount of lactose.

As cataracts in rats have been reported as the result of dietary deficiencies (vitamin G, vitamin C) as well as an overabundance of a dietary constituent as of lactose or galactose, indications are that there is a common cause, suggested by the Massachusetts Station investigators as a disturbance of the colloidal equilibrium in the crystalline lens by changes in inorganic ions. A normal amount of lactose in the diet has been shown by the Illinois Station, as noted above, to promote the deposition of calcium in the bones. An abnormal amount may disturb the equilibrium in the crystalline lens.

It would seem that the perfect transparency of the normal lens must be maintained by an extremely constant balance of inorganic ions and that any interference with the inorganic equilibrium might disturb the colloidal solutions and cause some of the proteins of the lens to precipitate.

The discovery that the normal crystalline lens contains vitamin C (ascorbic acid) and that the cataractous lens is lacking in this vitamin suggests the possibility that vitamin C may be involved in maintaining the necessary equilibrium, whatever may tend to upset it. On the chance that this is so, some oculists are already using ascorbic acid (pure vitamin C) in the treatment of incipient cataract.

Utilization of fats.—Because fats can be made in the body from other food constituents, it used to be thought that they were not absolutely necessary in the diet. Now it is known that fats are not only necessary constituents of the diet but that they differ widely in their usefulness. Recent studies at the Wisconsin Station have shown that different fats vary widely in rapidity of absorption in the process of digestion in the body. In feeding tests on rats it was found that while 70 percent of a given amount of cod-liver oil, halibut-liver oil, or the pure fat of butter was absorbed in 4 hours, only 60 percent of butter itself and from 50 to 60 percent of cottonseed oil, lard, corn oil, soybean oil, and hydrogenated fats were absorbed in the same time. All of these fats as well as all others melting at a temperature below 100° F. (slightly above body temperature) were completely absorbed by the body although different lengths of time were required. Fats melting above 100°, however, are absorbed not only more slowly but in some cases incompletely. If the fat is fed not alone but with other substances, absorption is sometimes delayed. On the other hand, the lack of certain vitamins in the diet slows up the rate of fat absorption.

Sparing action of fat on vitamin B.—It has long been known from rat-feeding tests that in the presence of considerable fat less vitamin B is required than in diets low in fat. Using the development of beriberi symptoms in rats as a measure of vitamin B deficiency, the Alabama Station found that on diets containing 40 percent fat, the average time for the development of symptoms of beriberi varied with the type of fat—from butter, 34 days, to pecan oil, 46 days.

To determine why different fats vary so in their sparing action for vitamin B, a series of single fatty acids such as are found in varying numbers and proportions in different fats was prepared and tested as had been the fats for these sparing effects. These acids likewise showed different sparing effects and several of the most effective ones were found capable of curing symptoms of vitamin B deficiency without the administration of any vitamin B.

Fortunately, the housewife in meal planning does not have to think very much about the amino acids in proteins, the different forms of carbohydrates, the fatty acids in the fats, or the relation of any of these to the vitamins in the various foods which she provides, for good advice on food selection is available to her from many sources. However, it is through fundamental research of the type noted above that clues are obtained which throw light on many baffling disorders, some of which have never been connected with faulty nutrition.

FOOD HABITS AND REQUIREMENTS

As noted in the 1934 report, some idea of the food requirements of different age groups may be obtained either by recording the kind and amounts of foods eaten over a period of time during different seasons of the year by people in good health and nutritive condition, or by conducting so-called balance experiments in which the intake and output of various food constituents are determined by chemical analysis. Several studies along these lines noted in the 1934 report as in progress have been completed and the station publications or journal articles reporting the findings are useful guides in food planning for adequate and in some cases optimal nutrition.

Food habits of young children.—The complete report of a previously noted investigation by the Ohio Station of the food habits and physical development of preschool children contains a wealth of information of value in planning diets for children of this age group. As all of the nine children made or exceeded the expected gains in weight and all but one the expected gains in height according to accepted standards during the 2 years of the study, their food habits may be used as a guide to food selection for this age group. With this in mind the Ohio investigators in preparing their report included in tabular form the complete data concerning the quantities of the specific foods used by each of the children during each season of the 2-year period.

One of the interesting findings in this study was the great variation in calorie intake (total energy of the food) of individual children from day to day.

Factors which seemed to influence a child's calorie intake were (1) the food intake itself—that is, the highest calorie intake either followed or preceded the lowest calorie intake in 36 percent of the cases; (2) the type of food served; (3) the onset of colds; (4) excitement and emotional strain; (5) the days of the week, the first part of the week being seemingly more conducive to high calorie intakes than the end of the week; and (6) the season, calorie intakes during summer and autumn being less varied than during other seasons. Suitable food selection for preschool children and control of the environment to prevent emotional states which disturb the daily rhythm of a child's life are important.

A study at the Michigan Station of the food intake for a total period of 60 days of a group of 20 children of preschool age yielded

results quite comparable with those of the Ohio study. These children made healthy or normal growth on diets containing on the average from 1 to 3 pints of milk daily (only three children drinking as much as 1 quart daily), one egg, a small serving of either meat or cheese, from one to two dishes of cereal, four fairly large servings of fruit or vegetable, and about 1 ounce of sugar and 1 ounce of butter. Very few of the children had olives or pickles. They had only small amounts of candy and practically no rich desserts. In general, the preparation of their food was simple.

Protective foods in the diet of school children.—On the theory that the adequacy of the diet of children is determined to a great extent by the amounts eaten of the so-called protective foods—milk, fruits, and vegetables—the Rhode Island Station secured records from 99 mothers of the servings of milk and different fruits and vegetables used during 1 week by one or more normal healthy school children in their families. In all, records for a single week were obtained for 106 children and for a second week at another season for 69 of the same children. The entire number of records was fairly evenly divided among the four seasons.

The consumption of milk ranged from three-eighths to eight 3-ounce cups per day with an average of 3.5 cups. However, more than one-third of all of the children drank less than three cups of milk daily. Fruits averaged 2.4 and vegetables 2.5 servings daily with a leafy green vegetable about five times a week. Nearly one-third of the group, however, had less than two servings of vegetables, including potatoes, daily. Apples headed the list of fruits in frequency of serving, followed by oranges and bananas. Potatoes were served nearly four times as frequently as the next vegetable on the list, tomatoes, which was followed in close order by carrots, lettuce, and spinach. In all 24 fruits and berries and 20 vegetables were listed.

Taken together the fruits, vegetables, and milk consumed daily furnished on an average more than the total requirement of calcium, a little under the requirement of phosphorus, and not quite half the requirement of iron.

Factors promoting good health in school children.—In an effort to learn why some children in a group are more healthy than others, information was secured by the Utah Station on the dietary and health history and environment of two groups of school children, classified on the basis of physical and dental examinations as more healthy and less healthy. No outstanding differences could be found in the health history or nutrition of the two groups. "There were, however, some small but consistent differences brought out, none of great significance by itself but which in the aggregate may influence physical well being." These included slightly better conditions at birth, better conditions of breast feeding, and more adequate supply of minerals and vitamins in the food, less sickness in earlier childhood and in the home in general, less crowded and better sleeping conditions, and better emotional atmosphere.

Nutritional needs of pregnancy.—All of the findings in the extensive investigation at the Oklahoma Station of the nutritional needs of human pregnancy, as shown by metabolism studies noted in the 1934

report, were published in bulletin form during the year. This bulletin is an excellent source of information on the metabolism of the various food essentials during pregnancy, and the conclusions which can be drawn concerning dietary requirements for this particular period. As a supplement to this investigation a special study was made of the effect of cod-liver oil as a source of vitamins A and D and a wheat-germ preparation as a source of the vitamin B complex on the retention of calcium, phosphorus, nitrogen, and iron during the latter part of pregnancy. The study, which was conducted on one subject, covered 101 days of continuously regulated diet during 82 days of which the diet was weighed. The retention of iron was improved by the wheat-germ preparation and this was also true of nitrogen. Cod-liver oil enhanced this effect but improved the retention of calcium, phosphorus, and magnesium only slightly. The subject purposely kept out of the sunlight during the entire period of study. As the retention of calcium was much lower than reported in earlier studies on a group of women receiving as much sunlight as possible during pregnancy, it was concluded that exposure to sunlight is more effective than cod-liver oil in conserving the much needed calcium.

FOOD ECONOMICS

During the past few years the rural homemaker has had to get along with a greatly reduced income. There is no very satisfactory measuring stick to use in determining how successful she has been in her management problems with the various items making up family living except foods, but with dietary standards fairly well established, it is possible to see how well she has managed to keep up standards with lowered income. Sound advice can also be given on food budgets. Several of the stations have taken advantage of the opportunities and needs of these changing years to obtain information on how farm families have met the emergency, and to prepare food budgets for the use of those who need help toward economical food selection.

The cost of protective foods.—In the Rhode Island study noted on page 113 the selection of protective foods by the mothers interviewed was scored according to accepted standards and the cost of the food supply calculated from current retail prices. The average cost per child per day was 18.5 cents distributed as milk 10 cents, fruits 5 cents, and vegetables 3.5 cents. There was considerable variation in the individual records from this average of nearly \$1.30 a week. Two records with protective foods costing less than 50 cents a week rated very low and in general with increasing cost the quality improved. However, an adequate supply of protective foods was furnished in 17 records on sums ranging from 50 cents to \$1 a week, showing that with intelligent thought, protective foods need not be expensive foods.

Food consumption of Wisconsin farm families in 1929 and 1933.—Food-consumption records obtained by the Wisconsin Station from over 300 rural families in three counties of the State in the predepression year 1929 and from the same families in the depression year of 1933 were compared for purchased and farm-produced foods, and for money costs with allowance for change in price level by adjusting

the 1933 figures to their value in terms of 1929 prices. The money value of food furnished by the farm increased during the 4-year period and that of purchased foods showed a corresponding decrease. The increase in consumption of foods from the farm consisted chiefly in a greater use of dairy products and meat, and to a lesser degree in fruits, home-prepared sugar and sirups, and lard. A few foods furnished by the farm decreased, particularly eggs and vegetables other than potatoes. The lessened money expenditures came chiefly from lowered consumption of purchased fruits, fats, and in two of the counties meats and butter. There was no decrease in coffee and a marked increase in cereals. Some of these changes tend to offset each other, others to improve and still others to lower the quality of the diet.

Decreased butter consumption has been accompanied by increase in consumption of cream. The danger in the decreased use of citrus fruits is probably offset by an increase in tomatoes. On the other hand the increased use of meat in a diet already high in protein foods may be of doubtful value. This tendency is only slightly balanced by a lowered consumption of eggs. The increase in white potatoes may operate to crowd out other vegetables such as the green and leafy kinds which should be used in greater quantity. The tendency to a too exclusively "meat and potato" fare, which is characteristic of many American dietaries, appears to have been increased by the depression adjustments of these farm families.

Winter food consumption in Wisconsin farm families.—A more intensive study of the relation of cost to adequacy of the diet was made by the Wisconsin Station in the winter of 1933-34 when records were kept of 1 week's food consumption of 109 families representing high, average, and low incomes per farm in three counties of the State. The average total cost per household (averaging 5.1 members) was just over \$10 for the week or \$2.29 per adult male unit. Of the cost, 32 percent represented purchased food and the rest the retail cost of food furnished by the farm. Analysis of the diets of 57 of the families showed a deficiency in one or more food essentials in all of the records. More of the diets were adequate as regards protein and fewer for iron than for any of the other constituents. Adequacy of the diet was closely related to the money value of the food supply. All of the diets costing less than \$1.50 per adult male unit per week were deficient in calories, iron, and phosphorus, and half of them deficient in protein and calcium. The diets costing as much as \$2.40 per week or a little over 34 cents a day had no deficiency in protein, calcium, and phosphorus and only slight deficiency in calories. At the highest cost, \$2.70 and over, iron alone was deficient. The greater adequacy of the more expensive diets could not be attributed to a wiser selection of foods but rather to the much larger quantities of food consumed. This fact shows the need of careful planning when costs must be taken into account.

Food budgets.—A definite food budget based upon the adequate diet at moderate cost of Stiebeling and Ward has been prepared by the Vermont Station for people in the State. The specific foods selected were those habitually used in the State, including home-grown ones where practicable and relatively inexpensive ones for purchase. The budget is presented in quantities required for 1 year by age and sex groups and the method of using it is illustrated by a sample food budget planned for a family consisting of husband, wife, and

two children. To determine the cost of the purchased foods, relative prices were obtained monthly during 1934 from various types of stores in communities of different sizes in three sections of the State and were weighted according to the net sales of each type of store.

Attention was called in the 1934 report to a study by the South Carolina Station of the food consumption of farm families in the Piedmont section of the State. The types and quantities of foods in both Negro and white diets, after analysis for adequacy, were used in planning adequate weekly diets conforming to the food customs of the section and utilizing to the greatest possible extent home-grown foods. The station is continuing the same type of investigation in another section of the State, the Coastal Plain section, where already interesting contrasts in food consumption habits are being shown.

HOUSEHOLD PRODUCTION V. PURCHASE OF CONSUMER GOODS AND SERVICES

With the advent of good roads and automobiles rural homes are less isolated than formerly from good marketing centers and many items, particularly foods, once universally made in the home can now be purchased. Certain services, such as steam laundries, are also made more accessible to the rural home. This raises many questions concerning the relative economy of continuing to make the home as self-sustaining as possible or of making use of some of the new facilities for lightening the homemakers' burdens.

Relative economy of home-made and purchased bread.—Bread is an important food item, the making of which is gradually being transferred from the home to the commercial bakery. To obtain some idea of the relative cost to Vermont homemakers of home production and purchase of bread the Vermont Station obtained information on bread-consumption habits and the time and money cost of home baking from 40 farm households in the State located from one-eighth mile to 8 miles from five market centers varying in size from a very small village with one store carrying one brand of bread to a city of 25,000 population. In addition, bread was available from trucks to 90 percent of the homes during the summer months and 75 percent during the entire year. It was found that in 55 percent of the homes most of the bread was baked at home while in 12 percent most of the bread and in 33 percent all of it was bought. The cost of home production of bread was estimated as closely as possible for 19 of the homes and found to be 4.3 cents per pound with no account of the cost in time, which amounted to an average of 6.3 minutes per pound. The average cost of 32 branded and 7 so-called home-bakery breads available for purchase was 7.8 cents per pound. From these figures it was calculated that had the 40 households purchased all the bread consumed in 4 weeks, the cost would have been \$4.01 per household as compared with \$2.21 for the same amount of bread made at home. In view of the very slight saving in cost and the rather poor quality of most of the home-made bread sampled, the Vermont investigators concluded that—

decisions as to the desirability of home production of bread should be made by individual households taking into account the monetary return, the pressure which the purchase of necessary or desirable goods and services places upon the cash income, the quality of bread which can be made, and the available time of the homemaker and her helpers.

The Nebraska Station has been conducting a study along similar lines of the comparative cost of home and commercially prepared white and whole-wheat bread and rolls, and the Vermont Station is now attacking the problem of the relative economy of household production and purchase of a few specific canned vegetables.

Home v. commercial laundering.—The burden of laundering at home can be greatly lessened by the use of power machinery, but the equipment is expensive and there is still a considerable outlay of time and labor. Commercial laundries have been greatly improved in recent years and are much more accessible to rural homes. The Washington Station has attempted to evaluate the time, energy, and money costs for the housewife when using different kinds of equipment, "old fashioned" and modern, and available commercial services offered by power laundries in the State. The general conclusions drawn were that the use of modern power equipment decreases the time and energy requirement in the performance of the weekly laundry task but increases the financial cost. Certain services now offered by commercial laundries make their use less prohibitive for the average homemaker than formerly, but when the laundry is finished commercially the weekly cost is still prohibitive for the family of average means. For the three most commonly offered unfinished family services (wet or damp wash, combination, and rough dry) the weekly cost for a family of five in the State of Washington ranged from approximately \$1.56 to \$2.73, depending upon the kind of service used and the equipment used in the home for finishing the process. Compared with these figures home laundering with fairly expensive equipment was estimated to cost approximately \$1.16, with less expensive power equipment \$0.77, and with hand equipment alone \$0.40.

Such studies as these are full of difficulties, for many intangible factors are involved as well as the more easily measurable ones. Perhaps their greatest value lies in showing how many things should be taken into consideration by the individual homemaker before deciding how much and in what ways she can lighten her labors by the purchase of various goods and services.

TEXTILE AND CLOTHING SELECTION

There are several types of research in textiles and clothing which will ultimately benefit the home through making possible a wiser selection of textile fabrics and clothing. One type consists in the physical and chemical analysis of textile fabrics for the accumulation of what might be called specifications for satisfactory fabrics of different kinds. Another is the study of the various factors affecting the service qualities of fabrics from manufacturing processes such as weighting of silk to conditions of ordinary wear such as sunlight, dry cleaning, and laundering. Still another is the examination of fabrics or articles of clothing to determine possible relationships between quality and cost and to detect misrepresentation in advertising. Then there is the field of clothing consumption with reference to the other items making up family living. Laboratory research in textiles at the experiment stations is limited by the fact that there are few equipped with the special humidity-control lab-

oratories which are almost a necessity in this work. However, several of the stations have recognized the importance of research in this field and have gone to the expense of installing such laboratories.

Studies on wool fabrics.—At the South Dakota Station wool from the tailless breed of sheep originating at the station was compared with wool from various other breeds after being used as the filling in specially woven flannels. In order of fineness only one of the breeds tested, Rambouillet, ranked ahead of the tailless, followed by Southdown, Shropshire, and Hampshire. The tailless, Hampshire, and Shropshire wools had high breaking and bursting strengths and resistance to abrasion while the Southdown wools gave low values. The flannel woven from the tailless wool had a very nice appearance and feel. The tailless sheep thus gives promise of being valuable as a source of wool.

Wool rendered "unshrinkable" by chlorination.—The effect of this process upon the strength of the wool under conditions of manufacture into fabric, ordinary use, and cleaning has been studied at the Iowa Station by exposing the material to dilute acid and alkali and subjecting it to the usual fabric tests. The chlorinated or unshrinkable wool was found to be weakened to a much greater extent by acids and alkali than was nontreated wool.

Samples of serges, gabardines, and dress flannels purchased in 1927 and 1928 from retail stores, jobbers, and mail-order houses were subjected to complete analysis by the Minnesota Station with the object of finding out if there were any significant relationships between the price per square yard of the material and quality which might be used as a guide in the selection of these types of wool fabrics. Only a few significant relationships were found. These were scattered and were different for all three groups of fabrics with the exception that in two of the fabrics (flannels and gabardines) percentage shrinkage in area decreased with increasing price. "It must be concluded, therefore, that price in the case of these three kinds of fabrics is not an adequate guide in selection on any basis except cost to the consumer." Even if this investigation led to no immediate practical advice to the consumer, the numerous analyses make an important contribution to information on the characteristics of woolen fabrics of different weaves.

Cotton fabrics and clothing.—A long-continued investigation at the Texas Station on the effect of sunlight on the strength and color of cotton fabrics was completed during the year. Some of the conclusions drawn from the investigation as a whole were that length of time of exposure of the fabrics to sunlight had the greatest effect upon loss in strength followed by temperature and relative humidity, that heavy fabrics were weakened less than lightweight, and dyed fabrics (with the exception of pink) less than white. The color changes did not depend upon the original color but on the nature of the dye and depth of dyeing. Fabrics guaranteed sun-fast underwent less change in color than those not guaranteed but fabrics guaranteed to be tub-fast were not necessarily light-fast. The station recommends that in purchasing cotton fabrics which are to be laundered, care should be taken that they are guaranteed fast to both light and washing.

White cotton fabrics of three different types.—Oxford cloth of fancy basket-weave construction, pique of rib weave, and cross-bar dimity

of fancy basket weave—selected in relatively high-priced and low-priced materials for each type were analyzed at the Ohio State University to see if there was any relationship between price and quality. As had been found true by the Minnesota Station for wool fabrics, there were no marked and uniform differences in quality between the higher-priced and lower-priced samples of the same type. “As judged by the uniformity of the fabrics in strength, the balance of yarns, and the amount of finishing materials used, price would seem to be only slight indication of the quality of these fabrics.”

White broadcloth shirts are such a common article for men's wear that standards to which they should conform have been recommended by the United States Bureau of Standards. Certain features required in a “perfect shirt” have also been reported to the trade after extensive research. To determine to what extent medium-priced shirts measure up to these standards white broadcloth shirts for men were purchased in duplicate at retail from different types of stores in Minneapolis and St. Paul and examined at the Minnesota Station. Nine of the eleven shirts were priced at about \$1.50 and two at about \$2. Eight were advertised as preshrunk and two as sanforized. Only 3 of the 22 shirts examined met the proposed commercial standards in every measurement and not one met all of the specifications of a “perfect shirt.” The collar bands were all longer than the marked size, and after laundering some of them were shorter than the marked size. Nearly all of the sleeve lengths were shorter than marked. After 25 washings only one shirt showed a shrinkage of less than 2 percent, the limit allowed. There was no consistent difference in the character of the fabric in the two price ranges, and a greater uniformity in stitching in the higher-priced shirts was the only noticeable construction difference. Consumer demand for recommended specifications for white broadcloth shirts seems to be greatly needed.

Silk fabrics and clothing.—Laboratory research on silk fabrics at the experiment stations has been concerned primarily with the effect of weighting on the wearing quality under various conditions. Some of the studies in this field are highly technical in nature and their value to the purchaser and user of silk fabrics is largely indirect. For instance, the ability of silks weighted in different ways to hold up under repeated dry cleaning and laundering is useful information for cleaning establishments but of little practical value to the housewife who has no knowledge of the nature of the material in her so-called silk dresses. The greater publicity that can be given to the results of studies which show some of the weakening effects of certain types of weighting, the greater will be the consumer demand for informative labeling of silk fabrics and garments. Studies along this line are being conducted at the Iowa and Kansas Stations and at Pennsylvania State College. One recently reported study at the Iowa Station will serve as an illustration. Plain-woven silk fabrics of similar construction and containing iron, lead, tin, tin-lead, and zinc weightings, and no weighting were subjected to the usual textile tests and after dry cleaning or laundering 33 times, were again analyzed. The fabrics weighted with the various metallic salts were found to react very differently on cleaning. The tin-weighted and tin-lead-weighted silks were weakened much more by dry cleaning

than by laundering. Of the five silks the tin-lead-weighted sample was most weakened by cleaning and the zinc-weighted silk withstood the cleaning the most satisfactorily.

Facts about silk hosiery which purchasers should know.—The results of a survey on the selection and care of silk hosiery by Montana women, and of laboratory and wearing tests on eight of the most commonly worn brands, and suggestions based on these tests as to factors affecting wearing quality have been published by the Montana Station as an aid to selection and care of women's hosiery. Among the suggestions made to the housewife are to consider the weight or thread number, look for evidence of twist in the silk yarn, examine reenforcement of the high splice, see whether the hose are firsts or irregulars, buy hose of correct size and suitable length, and prolong the wearing life of the hose by using correctly fitted shoes, laundering the hose frequently, and handling them carefully to prevent snags and runs.

HOUSEHOLD ENGINEERING

The study of household equipment, utensils, and processes for carrying on the various household tasks is receiving comparatively little attention at the experiment stations, only six of which (Indiana, Iowa, Maine, Nebraska, Virginia, and Washington) reported any projects in this field in their 1935-36 program. In one or two of the stations where equipment and personnel are available to carry on research in this field on a fairly large scale, comprehensive programs are being developed. As an illustration of some of the varied types of work included under the general heading of household engineering, recent progress at a single station, Virginia, will be noted.

Home-laundry investigations.—Among the points considered by the Virginia Station to be essential in the study of home-laundry processes were the comparative values of soaps with respect to cost, the economy of soft water, the relative washing ability of power washing machines of different types, the time and temperature factors of the washing process, and the selection of ironing equipment. While none of these special problems had been completed, some conclusions of value to the homemaker have already been drawn as follows:

The cheaper, bulkier soaps give no saving in cost over the more concentrated and apparently more expensive soaps. Fully half the soap required with hard water can be saved by using soft water and the saving will pay the interest on a mechanical water softener. Power machines of different types and makes have shown but little difference in ability to wash but may show differences in quality and durability. Washing machines can easily be overloaded and the washing will then be less efficiently done. A temperature of 160° F. for washing water was found to give the best cleaning of clothes but 140° gives nearly as good results and is much easier and cheaper to maintain in the hot-water heating equipment.

Nearly 2 dozen makes and types of electric irons have been examined for temperature while ironing and while the iron is standing on an asbestos block, consumption of electric energy under all conditions of use, performance and maintenance of ironing tem-

perature for high, medium, and low settings and on different kinds of cloth, action of thermostats, life tests of 1,000 hours and efficiency tests thereafter, and other points. These studies have shown among other things that thermostats on electric irons are exceedingly variable in their action and in actual service generally do not reach the claims of manufacturers. Only the irons with high wattages (800 to 1,000) will maintain the required ironing temperature. Much of the heat produced in an iron comes upward to the discomfort of the operator instead of going downward to the efficiency of the iron. The new lightweight irons seem to iron about as well as the older, heavier ones, and are operated more easily, but some of the new sales features have little practical desirability.

Development of low-cost electric cooking equipment.—This project, which is a part of a general investigation at the Virginia Station of heat in cooking, was originally undertaken as a civil works project under the Federal Farm Housing Service and continued as a station project with some assistance from the Tennessee Valley Authority with the main objective of producing inexpensive electric cooking equipment for the rural electric consumer. Electric hot plates for cooking have been designed and made with two 1,000-watt burners at a cost for materials of about \$4 or \$5 and with three burners or units at a cost of \$6. These stoves have been tested sufficiently to know that they will give good service. In comparisons with these a number of hot plates on the market, selling from 98 cents to \$4.95, proved to be of too limited capacity for family cooking and too flimsily built to give lasting service. Most of them began to show failures after about 60 hours of operation. A stove of this kind should have at least capacity (wattage) sufficient for family cooking and ruggedness enough to make it serve a year or more without repair.

Other types of cheap electric cooking equipment devised at the Virginia Station have been an electrified kerosene stove built at a cost of from \$5 to \$6 from an old kerosene stove, and electrified cheap ovens such as used with kerosene stoves. In these ovens, which have been fitted with special electric units, different temperatures are secured by turning on one or more of three switches connected with units of 600, 900, and 1,200 watts. The regulations of temperature in these ovens by turning on the proper wattage has been far beyond anything ever expected or required of a thermostat and is obtained without the cost of a thermostat.

HOUSING

The house is the center of family life, the meeting place of friends, and many productive activities are carried on here. The beauty, comfort, convenience, privacy, and spaciousness of a house and its facilities contribute much to the joy of living and the development of people who inhabit it. The recent increased interest accorded housing is the result of a growing recognition that in order to raise the American standard of living, something must be done to improve housing. To promote better housing it is necessary first of all to know the facts.

Farm, village, and town housing in Iowa.—The above quotation, taken from the foreword to a research bulletin of the Iowa Station on the Status of Farm Housing in Iowa, explains why the station felt it worth while to analyze in considerable detail the data for the farm

homes in the State available from the Federal housing survey noted in the 1934 report. As villages and small towns in Iowa are largely service and residence centers for farm communities and for retired farmers, the station conducted a similar survey of town and village housing in the State. The bulletins reporting both of these studies contain facts concerning Iowa housing conditions of interest to the farmers themselves, to all who are concerned with rural problems, and to manufacturers and distributors of building and home equipment.

The farmhouses, the majority of which were painted frame houses of about seven rooms, were greatly in need of repair and about one in eight needed to be replaced. Only about one house in five had a bathroom, one in four piped cold water, and one in eight piped hot water in the house. Slightly more than half of the houses had kitchen sinks with drains. In answer to the question, How would you spend \$500 if available for house improvement?, installation of water systems was most frequently mentioned, one family in five listing this as the most needed or desired improvement. Installation of bathroom equipment was given preference by about one family in six and improvement of interior walls, ceilings, and floors by about the same proportion. Repairs on exterior walls came next in order. Few families were willing to borrow money for desired improvements.

In the towns and villages painted frame houses also predominated but with a slightly smaller average number of rooms. Most of the houses needed some repairs and painting. About 6 percent of the houses needed replacement. About two houses in five had a bathroom and about the same proportion piped water. Many of the towns had no sewage-disposal system. Two-thirds of the families reported that less than \$100 had been spent in repairs and improvements during the past 3 years. Exterior walls were mentioned most frequently as the first place for repairs and improvements if \$250 were made available, with interior walls and water systems next in importance.

The situation in Iowa is probably representative of rural housing throughout the country after several years of depression. As is noted on page 125, house repairs received first attention in Illinois when a little extra cash became available in 1933-34.

Farmhouse plans.—The need of farmhouse replacement as brought out in the Federal housing survey has led several of the stations to develop new farmhouse plans. Additional plans, supplementing an earlier published series, have been prepared by the Arkansas Station with a view to meeting southern conditions and utilizing native materials in houses ranging from one to seven rooms in size and from \$250 to \$4,000 in cost. The majority of the designs are for three- to five-room houses at costs under \$1,000 in cash outlay. Preliminary studies indicate that more than 50 percent of the value of the house may be in the form of labor and materials contributed from the farm without cash outlay.

Air-conditioning of rural homes.—In the belief that air-conditioning of homes is one of the luxuries of today that will become one of the necessities of tomorrow, the California Station in cooperation with the committee on relation of electricity to agriculture has investigated methods of air-conditioning homes, particularly rural, in different sections of the State. In the bulletin reporting the results of this

investigation, much attention is given to insulation, for the expense of cooling as well as of heating houses is greatly lessened by proper insulation. For those who cannot afford to install any insulating or conditioning systems, suggestions are given for simple means of keeping out heat in summer. Various comparatively inexpensive means of insulating ceilings and roofs are also described. The data on the comparative cost of such insulation, when included in the construction of the house and installed later, show that the penalty incurred for not insulating during construction may amount to about 85 percent for a one-story cottage and 115 percent for a two-story house. In considering air-conditioning of homes a prospective necessity rather than a luxury, the station calls attention to the fact that—

arrangements especially for insulation and air ducts can be made in the beginning at little cost, which later prove not merely expensive but difficult; and also no more significant factor exists in this subject of economy than insulation.

EXPENDITURES OF FARM FAMILIES

Perhaps the greatest value of keeping family accounts is the possibility which it affords of year-by-year comparison of the amounts spent for the various items making up family living. For farm families account keeping involves records not only of cash expenditures but also of goods furnished by the farm. The past 4 or 5 years during which there have been such marked changes in cash income as well as in the purchasing power of the dollar have afforded an excellent opportunity to study, by means of family accounts, the extent to which farm families have been able to meet the depression by adjustments and curtailments in expenditures, and by a greater use of home-produced goods. Account keeping by Illinois farm families has acquired such a momentum as a result of the efforts of experiment station workers that there are many families from whom account books covering 5 or 6 years have been available for comparison. At other stations special studies have been made of the effects of the depression upon standards of living and of the particular adjustments which have been made to meet decreased income.

Standards of living of farm families in Nebraska, 1931-33.—One hundred farm families in three counties of Nebraska cooperated with the station in keeping family accounts for one or more of the years 1931, 1932, 1933. In all 183 records were obtained, including 58 for 1931, 69 for 1932, and 56 for 1933. There were 25 families who kept accounts for the entire 3-year period. The accounts kept by these families showed a 21-percent decrease in the average value of family living in 1932 from that of 1931 with a further decrease of only 1 percent in 1933.

The decrease in cash expenditures was twice as large as the decrease in value of the living provided by the farm. In order of size of percentage decrease in 1932, church and charity ranked first; and gifts to persons outside the family, supplies and equipment, clothing, and purchased food followed in the order listed. The largest decrease in value of a single item was in food. In 1933 there was a further percentage decrease in church and charity, supplies and equipment, and water and telephone. The expenditure for health was greater in 1932 and less in 1933 than in 1931. The decrease in the net cash income lowered the amount for savings in 1932, and a further decrease occurred in 1933, which, translated into family practice, meant allowing insurance policies to lapse.

Not all the effects of the depression can be measured in dollars and cents. The Nebraska Station found among some of the families studied a distinct lowering of standards of living and morale with a growing spirit of pessimism and dependence. On the other hand, there were also those

who were still hopeful that better times would come. Courage and perseverance marked their approach to the problems of each day. Some found comfort in recognizing that they were not alone in looking for solutions, while others summoned all of their intelligence to meet the crisis. * * * A leveling of income and a recognition of common problems appeared to reduce to a minimum any tendency toward class distinction or a division between more and less successful families. The futility of depending upon individual effort and the need for group endeavor were apparent.

How farm families in Wisconsin met the emergency.—Through revisits in 1933 to as many as possible of the families in three counties in Wisconsin who had cooperated in a standard-of-living study in 1929, the station was able to find out in what ways these families had made adjustments to lowered incomes during this period. When 1933 prices were adjusted to 1929 price levels, it was found that the purchased items in family living showed decreases of 28, 14, and 20 percent, respectively, for the three counties studied while items furnished by the farm had increased by 8, 10, and 21 percent. As noted on page 114 much of the increase in goods furnished by the farm was in certain types of food. In the main the families lived in the same houses in 1933 as in 1929 but little had been done in the interval in the way of greatly needed repairs and fewer rooms were used the year around on account of the cost of heating them in the winter. Expenditures for furnishings, equipment, and clothing were greatly reduced. There was a significant reduction in the use of the automobile, telephone, and radio, and less money was spent for barber's services, reading matter, recreation, gifts, and church support. Less money was spent for health maintenance but more for health and life insurance.

In spite of these many retrenchments approximately two-thirds of the families in two of the counties and four-fifths in the third did not have enough cash to cover family-living costs. This meant in some instances indebtedness to the extent of several hundred dollars, while others had turned to relief for subsistence for themselves or their livestock. Commenting upon the findings in the study, the Wisconsin Station concludes that—

farm families are valiantly attempting to adjust themselves to curtailment in their economic circumstances. They are encountering many difficulties. Some are hopeful, and some discouraged, but all are trying to hold on even at the cost of lower standards of living, in sacrifices of family habits and traditions, and in a retrenchment from many values which were formerly regarded essential.

How Illinois farm families spent the increased income of 1934.—The Nebraska and Wisconsin studies noted above covered the worst years of the depression. What probably happened in these and other States during the year 1933-34 may be predicted from what actually happened in that period in the Illinois farm families, who, as noted on page 123, have been keeping accounts over a number of years. For the 167 farm families whose 1933-34 accounts were analyzed by the Illinois Station, the total average money value of living and

savings was 5.9 percent higher than for 159 farm families whose accounts for 1932-33 had been analyzed previously. Included among these record keepers were 50 farm families who had kept accounts for 4 consecutive years. Their average realized income for 1933-34, \$1,606, was 8.7 percent higher than for the preceding year and the increase was chiefly in available cash. How did these families spend this additional cash? Repairs on the farm dwellings, furnishings, and equipment apparently came first, for the average amount spent per family on these items was nearly three times the amount spent the year before. Automobile expense (chiefly new cars or used cars of a later model) increased 26 percent and clothing 18 percent. All other general expenditures including saving increased slightly with the exception of church, which showed a slight decrease.

SYBIL L. SMITH.

IMPROVING RURAL ECONOMIC AND SOCIAL CONDITIONS

An outstanding development of the year in the field of agricultural research was a synthesis of available data bearing on the problem of agricultural adjustment and planning. In a study of agricultural adjustments in farming by types-of-farming areas from the standpoint of agricultural adjustment and planning, including soil conservation, all of the State agricultural experiment stations cooperated with the Bureau of Agricultural Economics and the Agricultural Adjustment Administration in harmonizing a vast amount of technical and economic information and indicating problems requiring early attention to complete the body of knowledge required in agricultural adjustment and planning beyond the emergency period.

This synthesis, carried out for the country as a whole, is to be followed up by a similarly comprehensive cooperative research undertaking designed (1) to supply needed data from the several subfields of agricultural science, and (2) to determine for the various type-of-farming areas of each State the nature and extent of desirable adjustments in agriculture designed to assure appropriate combinations of crops, pastures, and livestock on individual farms and at the same time to secure the best use of land, improve soil productivity, and to conserve agricultural resources in a manner consistent with rural standards of living and national goals in crop and livestock production.

This more intensive study of forces influencing adjustment, criteria, and procedure is designed to supply a basis for desired adjustments brought about through either present institutional arrangements or such modifications of them as may prove desirable in the different agricultural regions of the country.

In the field of rural life, much emphasis was placed on the investigation of problems affecting rural welfare. Of 50 projects active during the year at the State agricultural experiment stations, 4 dealt directly with this subject, 5 with rural population, 3 with standards of living, 2 with rural-urban relations, 6 with rural organizations, 1 with rural institutions, 15 with community and regional studies, 12 with the rural family, 1 with social psychology, and 1 of a general nature. The interest originally noted in studies of the rural family, including the interests and activities of rural youths, has continued to grow. While the depression has tended

to concentrate interest upon problems of destitution and relief, there is now developing a more positive emphasis upon improvement in standards and planes of living.

The study of rural-life problems has been stimulated during the past year by the activities of the Federal Emergency Relief Administration, which cooperated with 25 State stations in an extensive study of current changes in rural relief and related problems. In addition, this organization cooperated with instructional divisions of three other agricultural colleges and had its own temporary investigational set-ups in eight other States, where formal cooperative relations with the colleges were not entered into. Thus, this organization conducted relief surveys in some 35 States during the year and contemplates cooperative relations with several additional States during the forthcoming year.

FARM BUSINESS AND FINANCE

Illustrative of the improving factual basis for adjustments in agriculture, the following summaries of the published results of research at the State experiment stations reported during the year are cited:

Effects of changing economic conditions on farming.—The Indiana Station reports an investigation which showed 100 farmers in Clinton County had an average farm income above operating expenses (not including interest on their capital or value of their own labor) of \$493 in 1932 as compared with an average of \$2,534 for 100 farms during the war period (1916–19) and \$1,407 for 100 farms during the pre-war period (1910 and 1913–15). These differences were caused largely by widely changing price levels. The quantity of all products sold from 100 farms in 1932 was about 10 percent greater than from 100 farms in the pre-war period, but prices received for them were about 37 percent less. This resulted in farm receipts only about 70 percent as large in 1932 as in the pre-war period. Operating expenses were 13 percent more in 1932 than in the pre-war period, leaving a farm income only one-third as large. Other factors appeared to play a minor or incidental part.

Research on the economic aspects of agriculture.—The trend of agricultural research, as evidenced by requests that came to the Pennsylvania Station for assistance, is towards studies on the economic and social aspects of agriculture. It is pointed out, however, that the basis of successful agriculture is efficient production and that the Pennsylvania Station will continue to be concerned with the solution of problems relating to production and extending the boundaries of knowledge in the sciences on which the practice of agriculture rests. While giving consideration to proposed projects an effort will be made to keep a reasonable balance between problems in production and in marketing and to maintain a strong program of fundamental research in both the natural and social fields.

Real-estate assessments.—From an analysis of records of 2,173 land sales in 28 counties during the year 1930, the Virginia Station found a noticeable tendency for properties of high sale value to be relatively underassessed and for those of low sale value to be relatively overassessed. This was generally true regardless of the cause of the

value. High valued properties were underassessed whether the high value resulted from a high land value per acre or a large proportion of the value represented by buildings. However, the greatest variations in the ratio of assessed to sale value were found on small acreages. Small properties of low sale value per acre were generally assessed for more than their sale value, while small properties of high sale value per acre were generally assessed at much less than their sale value.

Assessed and sales value of Nebraska farm land.—From a study of assessed and sales value of farm lands, the Nebraska Station concludes that in the northwestern half (approximately) of the State the assessment ratio, that is, the ratio of the assessed value to the sales value, increased from 42 to 67 percent during the period studied. The tracts that sold for the lower amounts were especially overassessed; in the case of those selling for \$1,000 or less the assessment ratio was 86 percent during the year 1926-27 and 184 percent during the year 1933-34, and above 100 percent in 9 of the 13 years. The more valuable tracts (\$15,000 or more) were assessed at from 34 to 53 percent of their sales value during the years studied. In the southeastern half of the State (mostly Corn Belt area) the assessment ratio was 53 percent in the first year studied, 87 percent during the year ended March 31, 1932, and 79 percent in the following year. Here the less-valuable tracts fared badly, although not so badly as in the other half of the State. The ratios for tracts valued below \$2,500 ranged from 90 to 137 percent, while the better tracts (\$30,000 and over) were assessed at from 48 to 76 percent of their sales value. In every district and in every year the cheap land was overvalued by the assessors. Because of this the poorer farms had to pay a disproportionate share of the taxes.

Land evaluation.—The California Station has developed what is known as the "Storie index" of evaluating soils in land appraisement.

In this method a factor value is given to the characteristics of the profile and particularly of the subsoil horizons; a second factor value is given to the characteristics of the surface soil, particularly with reference to texture and structure, which control the ease with which seedbeds are prepared, the rate of penetration of water and similar reactions; while a third factor covers any unusual conditions not presented by the profile, as, for instance, exceptional conditions of alkali or acidity, poor drainage, excess stone, and the like. The three factors are then multiplied, the result being the index value. A rating of all of the soils of the State of California which have been covered by soil surveys has been worked out and prepared for publication.

Purchasing farms.—Some helpful suggestions to prospective purchasers of farms are made by the Minnesota Station as a result of its study of agricultural lands in that State. The station finds that poor farms are usually undervalued as compared with good farms. It suggests, as aids in arriving at a correct opinion as to the value of a farm, soil maps, condition of growing crops, kind of crops raised, financial success of previous operators, amount of livestock that has been carried, opinions of neighbors, nature of buildings, location, and the amount of unimproved lands.

One method of determining value is to assume that a farm is worth the sum upon which the customary share of the landlord will earn the rate of interest usually paid on a farm mortgage, after allowing for taxes, depreciation of buildings, and other expenses customarily paid by the landlord. For example, at 5 percent, if the landlord's net return would average \$400, the farm would earn interest on \$8,000.

The station advises a cash payment of one-third or one-half of the purchase price unless an unusual bargain is being secured.

If one has purchased a farm and finds it impossible to keep up the payments, he should never mortgage execution-exempt personal property as security for unpaid interest and taxes. In almost any community there are cases where this has resulted in the loss of both the farm and all personal property. If one has a small outfit of personal property, he can usually make a new start as a tenant. If he has only his hands, he may be reduced to the status of a common laborer.

Property-tax trends.—The South Dakota Station finds that in that State the school districts levy the greater share of the gross tax.

Tax revenues close to \$4,000,000 were required to operate the schools of the State in 1915. This figure rose to \$13,134,387 in 1920 and remained fairly constant for the decade at a figure of approximately \$14,000,000. The school districts evidently require almost as much tax support as the counties, townships, and cities combined. In keeping with the other units of the government the school district taxes were materially cut after 1930. The counties rank second to the school districts in gross taxes levied. The State and cities and towns appear to vie for third place with the townships last. In absolute amounts levied, the county taxes are far greater than those for State purposes, but they remain more nearly constant after 1921, while State taxes continue to increase. While the State levy ranks third in gross amount, nevertheless it shows a greater increase and also more fluctuations than any of the other units. In 1915 the State levy was \$1,268,269. It had reached \$5,348,112 in 1929 and had only receded to \$4,790,470 by 1932 when the State levy was superseded by the gross income tax.

The increases and decreases in taxes of the various units are shown. The State levy shows the greatest increase while it declined after 1928 at a decreasing rate.

Taxation of intangible property.—An investigation made by the Texas Station revealed—

gross inequalities in the taxation of tangible compared with intangible property. The seriousness of these inequalities becomes more intense as the size of estates increases because of the concentration of intangibles in the larger estates. Similarly, rural communities bear a disproportionate share of government costs compared with town and city communities because of the concentration of intangibles in the latter.

The escape of intangible property from taxation is especially significant because such property constitutes a substantial proportion of all property. It was found that—

Tangible property constituted 54.1 percent and intangible property 45.9 percent of all property probated. Tangible property constituted 97.1 percent of the property assessed for taxation for State and county purposes in the 47 counties studied, and intangible property 2.8 percent. Of all real estate probated 17.8 percent was in estates of \$500,000 and over, while of all intangibles probated 33.9 percent was in estates of \$500,000 and over, thus indicating a rather high degree of concentration of intangible property in large estates. Intangible property constituted 31.6 percent of the property probated in rural communities, 38.4 percent in town communities, and 50 percent in city communities. In recently developed agricultural areas intangibles made up only 12.6 percent of the total, while in older urban areas intangibles constituted 52.6 percent of all property probated.

Real estate taxes in Kentucky.—Farm real estate taxes in Kentucky increased from 16 cents per acre in 1913 to 44 cents in 1923 and declined to 33 cents in 1933 as compared with 24 and 46 cents, respectively, for the United States as a whole. The rate per \$100 of value

rose from 51 cents in 1913 to \$1.18 in 1933, differing little in net change from that for the United States as a whole.

Generally, the indexes of farm real estate taxes decreased most in recent years in those counties where the greatest increases had previously occurred. Conversely, the indexes decreased least in those counties where the smallest increases had occurred. Moreover, farm real estate taxes rose less in the wealthier than in the poorer counties when taxes were rising, and fell less in the poorer counties when taxes were falling.

Michigan tax laws.—A comprehensive handbook of Michigan tax laws has been compiled by the Michigan Station to aid the State Tax Commission. Distribution and use of the different classes of tax funds are explained. Rural taxation is not especially emphasized. This is one of many examples of calls on the experiment stations for aid in dealing with State tax problems and use of tax funds in a broad way.

Tax delinquency in Arkansas.—A study by the Arkansas Station of tax delinquency in the State, covering the period from 1928 to 1933, indicates that the condition of delinquency became serious in 1931 when 4,000,000 acres were delinquent. This work was done in co-operation with the Department of Agriculture on a grant of funds by the Public Works Administration. By 1933 about 9,000,000 acres were either delinquent or had been forfeited. The indication was that delinquency was just as prevalent in good-land areas as in poor-land areas. The causes of delinquency, it seems, in addition to the effects of the depression, lay chiefly in deficient tax titles and indifferent tax administration. A special study of public-school finances showed a marked decrease in revenues from 1931 to 1933. About 30 percent of the districts in 1933 had no school at all, or operated for only a short period. Bonded debt was confined to about 10 percent of the districts, but in some of these districts debt service requirement took 90 percent of current revenues. Rural districts generally were most affected. The State legislature has made frequent use of the results obtained from these studies, partly in revising the law pertaining to tax collection and tax administration and partly in finding new revenues for public schools.

Tax delinquency in Georgia.—From a recent study, the Georgia Station, in cooperation with the Department of Agriculture, finds that the number of tax-delinquent acres in that State increased from 3,500,000 in 1928 to 6,500,000 in 1932, with a small decrease in 1933. This delinquency represented 30 percent of the total acreage in the counties studied in 1928, 57 percent in 1932, and 51 percent in 1933.

Land tax delinquency in Missouri.—Cooperating with the Civil Works Administration and the Department of Agriculture, the Missouri Station found that—

Currently unpaid property taxes for 105 of Missouri's 114 counties rose from \$3,577,610 in 1928 to \$5,827,044 in 1932, despite the fact that tax levies decreased during the same period from \$28,443,640 to \$22,762,193. The percentage of current levies delinquent in these same counties increased from 12.58 percent in 1928 to 25.60 percent in 1932. Both the volume and the percentage of current delinquency decreased in 1933 as compared to 1932. * * * Acreage delinquency in 92 counties for which data were available increased from 4,514,504 acres in 1928 to 10,163,319 acres in 1932. * * * Delinquency has apparently been about as great in the towns and cities of

the State as it has been in the rural areas, and urban delinquency was higher in 1933 than in 1932. The acreage of lands sold for taxes in 108 of Missouri's 114 counties averaged a little less than 100,000 acres per year for the period 1928-1932. Receipts from the sale of lands foreclosed for taxes have been so small in recent years as to barely cover the cost of tax suits, and have brought in almost nothing in terms of public revenue.

Tax delinquency in New York.—Data collected by the New York (Cornell) Station in 235 towns in 15 counties showed a significant decline in tax delinquency in New York following 16 years of increasing delinquency. Towns in which individual wealth averages less than \$1,000 showed the highest percentage of delinquency in all years. Towns with no incorporated villages and those with more than three-fourths of the population in incorporated villages had more taxes in arrears than did towns in intermediate groups. Towns with a small rural population and those with a large rural population stood relatively high in tax delinquency. Towns with a population of less than 25 to the square mile and those with more than 100 persons to the square mile had a greater proportion of tax delinquency than those in intermediate groups.

Tax delinquency in Texas.—In a survey of 120 selected counties of Texas, in cooperation with the Department of Agriculture, the Texas Station found that the number of tax-delinquent farms had increased from 33,267 in 1928 to 124,192 in 1932, and that the amount of delinquent taxes was \$141,783,000.

The more important causes of tax delinquency were declining agricultural as well as other commodity prices and rising taxes; faulty assessment and collection practices; periodic remission of penalties and interest; the uncertainty of tax titles; the indifference, procrastination, or misfortune of the taxpayer; and finally, the failure of the tax system to include and properly harmonize the two fundamental bases of taxation—benefit and ability.

Among the more important changes recommended by the station are:

An active and responsible participation by the State in the assessment and collection of taxes; the keeping of a complete and continuous inventory of taxable property by counties; that collection procedure be made simple, certain, and convenient; that court procedure relative to tax sales be simplified and harmonized with the enforcement of tax laws; that penalties be reasonable and certain and their remission be avoided; and finally, that collectors be appointed on a competitive basis.

Farm-land and debt situation in Iowa.—The Iowa Station states, as a result of a recent study of the farm-land and debt situation in that State, that corporate-owned land amounted, on January 1, 1935, to 10.1 percent of the 34,000,000 acres of farm land in the State. Insurance companies owned over half of the corporate-owned land, with deposit banks the second largest holder. The Iowa farm-mortgage debt was reduced \$74,000,000 in 1934, leaving a total of \$924,000,000, of which 40 percent is held by insurance companies, 26 percent by the Farm Credit Administration, and 12 percent by banks. The debt per acre was \$63 at the close of 1934 as compared with \$66 in 1933. Since 1933 there has been a reduction of 2 percent in farm land mortgaged, leaving 43 percent still mortgaged. There were 3,900 foreclosures in 1934 as compared with 3,700 in 1933 and 6,400 in 1932. Insurance companies were responsible for 67 percent of the fore-

closures, private investors 17 percent, banks and miscellaneous lenders 16 percent. Judgments totaled \$49,000,000 on approximately 1.8 of all farm land in the State. Farm tenancy increased from 54 percent in 1927 to 59 percent in 1933. The station reports that more land sales occur in years of high land prices than in years of low land prices, and suggests the need of a policy encouraging the purchase of farms at low prices and the paying off of mortgages during good times.

Farm-mortgage loans.—The South Dakota Station reports that the volume of farm-mortgage indebtedness in that State rose from \$731,537 in 1910 to \$2,702,565 in 1920, and then declined to \$1,829,517 in 1930.

The acreage under mortgages was 35,139 in 1910, 45,316 in 1920, and 40,211 in 1930. * * * It was the debt per acre rather than the number of acres under mortgage that increased most rapidly. The average indebtedness per acre increased rapidly from \$20.82 in 1910 to \$59.64 in 1920, and at \$45.50 per acre in 1930 was more than twice as large as in 1910. * * * Foreclosures came only after 1920. During 1921–1925, inclusive, they amounted to \$346,135, and during the next five years ending with 1930, inclusive, the amount was \$171,465. During the ten years following 1920, 19.2 percent of the 1920 indebtedness was terminated by foreclosure. During the same period 25.6 percent of the 1920 incumbered acreage was foreclosed.

Chattel mortgages.—With the aid of the Federal Emergency Relief Administration funds, the Oklahoma Station made a study of chattel mortgages in 11 Oklahoma counties. It found that during the period November 1, 1933, to October 31, 1934, a total of 34,753 chattel mortgages for an amount totaling \$9,001,781 were filed in the 11 counties. The average size of all these loans was \$259, but nearly 16 percent of the total were for amounts less than \$150. This information has been of particular interest to the Farm Credit Administration since it has such an important bearing on the operation of the production-credit associations and is important likewise from the point of view of costs of handling farm credit. National banks were by far the most important mortgagees and handled nearly 28 percent of all farm chattel mortgages filed in the 11 counties. State banks were next in importance, but they held only about half as much farm chattel-mortgage paper as national banks.

Bank failures.—A study of bank failures by the Arkansas Station, cooperating with the Department of Agriculture, indicated that the difficulty with most of the banks arose before the depression when liberal loans were made on unsound security. Contrary to common opinion, it was found that less banking difficulty arose from farm loans than from other types of loans. The remedies suggested are limited liquidity requirements, the limitation of time and savings deposits subject to withdrawal on short notice, and the segregation of good assets for the special protection of depositors who accept long-time contracts and to allow no transfers from this protective fund except with the permission of supervisory officials. The station says that—

Viewing developments at large, it seems clear that banking difficulties have resulted mainly from the failure of banks to maintain a proper relationship between their quick assets and their current liabilities. Too large a portion of the liabilities has been payable on demand or at short notice; too small a part of the assets has been convertible quickly into cash. The remedy is to increase the proportion of liquid assets and decrease the proportion of liabilities payable at short notice. Banks can remain open indefinitely during favor-

able times with their assets in precarious relationship to their liabilities, but adverse conditions quickly destroy the slender margin of safety possessed by such institutions and force them to close. The public interest will never be served adequately until banks are ready at all times for emergencies; and the best time to prepare for emergencies is during periods of recovery and prosperity.

County finance and government in Montana.—The Montana Station found that about 85 percent of county-government receipts in that State is secured from the general-property tax; about 7 percent from motor-vehicle licenses; about 4 percent from fees, gifts, rents, interest, and earnings of general departments; and 4 percent from miscellaneous sources. The total receipts of all Montana counties amounted to \$27,632,000 in 1933, of which \$13,326,000, or 48 percent, was collected in trust for other governmental agencies within the State. The total net debt amounted to \$10,192,000, or \$18.96 per capita, in 1933 as compared with \$23,737,000, or \$43.24 per capita, in 1922.

The principal weaknesses in Montana county government appear to be: (1) The absence of any effective coordinating agency; (2) the many independent, elective, administrative offices; (3) the lack of special qualifications or training to hold county office, with minor exceptions; (4) short terms of office; and (5) the numerous counties with small valuation. To correct the present weaknesses and also to establish centralized direction and coordination of county government in Montana, a thorough reorganization of the present system is needed.

Financing public schools.—Financial support of schools is a matter of deep concern to rural people, as well as others. A study by the Arkansas Station of the present public-school situation in that State indicated that, while the public-school expenditures rose from \$1,369,000 in 1900 to \$15,733,000 in 1930, present support of the schools is wholly inadequate and the percentage of earned income spent for education per pupil is less than in any neighboring State except Tennessee. In 1924, however, the State began to supplement its sources of income, first with the severance tax and later with the tobacco and income taxes, and State support soon rose to about 40 percent. Since 1927, the State's part of school revenues has declined until in 1933 the State's share was the same as in 1923, 26.1 percent. Now, with the willingness of the State to assume a larger part of the responsibility for public education, the tax methods used during depression years have proved unreliable.

As a result of the revenue shortage, school terms in practically all rural districts have been reduced and some schools have been forced to close. Town and city schools have been able to maintain the usual school term only by drastic reduction in teachers' salaries, by overcrowding class rooms, and by eliminating supervisory and other activities. The ultimate effect, if present conditions were continued, would be to lower the standards of public school training and to deprive some children of any educational opportunity.

Among suggested tentative measures, are thorough-going revision and strict enforcement of both property and special tax laws, and reorganizing operating units for greater economy and efficiency, but the general conclusion is that "for the present, at least, new sources of revenue must be found and a heavier tax burden sustained if the school system is to serve satisfactorily the educational needs of the State."

RURAL LIFE DEVELOPMENT

The following summaries of station publications and director's notes are indicative of the improving factual basis for adjustments in rural life:

Increase of research in rural welfare.—The stations have recently been placing particular emphasis on studies of rural social conditions and standards of living. The advantage to be gained from concerted natural science and social science attacks upon the problems of distribution and consumption, as well as upon those of production is being especially emphasized. There was noteworthy increase in studies in rural welfare from 1924 to 1930. There was something of a slump in 1931, but a revival of interest thereafter, especially in sociological service, however, rather than in research. There were fewer projects in 1932-33 than in 1933-34, but the money allotted was greater in the former than in the latter year, indicating an effort to do more research or carry more projects on less money. In general, the situation is this: There is a growing appreciation of rural sociology. In recent years this appreciation has been manifested in a gradually increasing and constantly improving number of projects. At the present moment this appreciation is expressed in emergency sociological service rather than being fully reflected in rural sociological research projects. The outlook appears to be increasing emphasis upon problems affecting social groups, especially standards of living, community studies, rural-urban relationships, health and welfare, and rural social pathology, including, of course, both rural destitution and rural relief measures.

Rural social organization in Arkansas.—A study by the Arkansas Station of rural social organization in south-central Arkansas in a relatively infertile upland-cotton area showed that farm families in all their participations and services went about equally to open country and cities but less to villages. Most confined to open country neighborhoods were religious and social activities and elementary education. The cities led in newspaper, health, economic, and recreational services. No activities were chiefly village centered, but the farm people depended on villages for secondary education and economic services more than for other things. Factors associated with kind, amount, and place of participation were as follows in the order of importance: Age, tenure or economic status, and automobile ownership. While automobile ownership stood third in importance, it was associated with a marked preference for cities over villages as trade centers.

Economic and social problems of the southern Appalachians.—A report on a 3-year study (1931-33) of economic and social problems and conditions in the southern Appalachians, by the Department of Agriculture cooperating with the Office of Education of the Department of the Interior and the agricultural experiment stations in Tennessee, Virginia, West Virginia, and Kentucky, shows that the basic problems of the region grow out of maladjustments in land use and in the relation of population to land, and states that—

tangible adjustments in the utilization of the land cannot be effected unless there is a planning agency vested with powers and resources sufficient to cope with actual problems.

Effective solutions of the major land problems of the region

can be anticipated only if it be assumed that land utilization is to form the basis of a national agricultural policy and that a national organization will be established with authority competent to give effect to that policy.

The report points out that—

The character of the food supply is not infrequently the crucial factor in determining the quality of family living. Upon the nutritional adequacy of the diet depends the health and working efficiency of the individual, and upon the abundance and variety of food depends the success of social functions centering around the family table.

Insofar as the data obtained in this study can be accepted as representative—

It would appear that families in this region eat a very high cereal diet in the summer as well as in the winter. The quantity of milk they use is extremely variable; some families have a generous supply and others have too little for dietary adequacy. They consume a fair variety and quantity of vegetables and fruits in summer, but they can relatively little, so that potatoes, dried legumes, and dried fruit are the foods chiefly available in winter. Even in summer, when gardens and pastures are at their best, not all families enjoy nutritionally adequate diets. * * *

Throughout the southern Appalachians educational programs are needed to spread a knowledge of food values and nutritional needs. Home food-production practices that would develop food resources to best advantage should be encouraged. Gardens, cows, poultry, and pigs are necessary to furnish the vegetables, milk, eggs, and lean meat essential to the diets of individual families. Nutritionally adequate diets would materially raise the level of living in this region, and would make "possible for a much larger proportion of all people that full measure of health, happiness, and efficiency which only the most fortunate now enjoy."

Trends in country neighborhoods.—As a part of a larger national study made by the President's Committee on Recent Social Trends, the Wisconsin Station made a careful restudy of a typical country neighborhood in that State which had been studied 10 years before. This study showed among other things that—

Country people are maintaining their own groups and organizations. Evidence of this is the persistence of country neighborhoods and the continuance of local social activities. This is true despite the fact that during the past ten years farmers and their families have come to associate more closely and in more relationships with village and small-town people and that they frequent cities more often than formerly. With the increased facilities for communication and travel, the greater mobility of both country and city people, the passing of the older or pioneering families and the loosening of kinship and nationality ties, country groups are now more a matter of deliberate choice, of kindred interests, of belonging, or of organization than of locality, of proximity of residence, of tradition, or of "just neighboring." Yet, locality and living nearby continue to play their part and the traditions and backgrounds of the older group loyalties are in evidence everywhere in the persisting and even in the newer country neighborhoods.

The station concludes that the trends discovered in this study can be compared or contrasted with those of the Nation as a whole to the effect that in general the country neighborhoods and local group activities are in many respects persisting.

The New York (Cornell) Station finds that agriculture in New York State is being carried forward by the same type of population with only a slight geographic shifting, thus giving the rural areas a stable social organization, and that farming shows a greater tendency to be handed down from father to children than any other major occupation. Farming as an occupation was transmitted from fathers

to sons in 33 percent of the instances as against 9 percent in other occupations. It appears, however, from the station's study that agriculture can employ only 30 percent of the children reared in farm families.

Rural homes for nonagricultural workers.—The Ohio Station has collected data which indicate that—

the standards of living of many individual families with urban employment may be raised by moving to rural homesteads [but do] not support the conclusion that the public relief and unemployment problem would be solved to any great extent by attempting to make farmers out of the urban unemployed. The people included in this study were considerably above the average, judging from their educational background and occupational and economic status. It is hardly to be expected that a random sample of unemployed day laborers from the city would meet with anything like the same degree of success.

Urban influence on rural population.—The pronounced influence of a large city on the surrounding rural population is brought out in a study reported by the New York (Cornell) Station.

The strength of certain areas as indicated by the proportion of residents who go to the respective area centers for the service which the area represents, varies directly with the size of the center. In the hardware, motion-picture, drug, banking, work-clothes, and garage areas, there is a decided tendency for the families who do not obtain the service which the area represents in the center of the given area in which they reside to go to Syracuse (the county seat of Onondaga County, with a population of 209,326) for this service. In the church, grocery, and physician areas, the city exerts a minimum of influence; a low percentage of residents in these areas, except in the Syracuse area, go to Syracuse for church, grocery, and physician services.

The purchase of commodities by mail order does not appear to have appreciably weakened the areas for work clothes and hardware. This type of buying appears to be most used in the areas of the small places.

Rural population in New England.—The total rural population of New England in 1930 was 7,400,000, according to the United States Census. The Connecticut (Storrs) Station points out that it had declined 4.8 percent since 1920. In the meantime, the rural non-farming population had increased 1.9 percent for New England as a whole, but not uniformly for the different States. The station's studies show that the nonfarming rural population is increasing and is already large enough to be of distinct economic and social importance. For example, the rural nonfarming population of Connecticut is 24.6 percent of the total rural population. Apparently conditions are favorable for the growth and development of the non-farming rural population, giving rise to many complex problems of economic and social adjustment.

Part-time farming in Connecticut.—The Connecticut (Storrs) Station finds that 60 percent, or over 20,000 of the more than 30,000 farms in Connecticut, are operated on a part-time basis and that these farms are widely scattered over the State among full-time commercial farms and homes of nonfarmers. The greatest density of part-time farms per square mile is in the areas of urban and industrial development. Other things being equal, there are more part-time farms per square mile and a lower percentage of the total

number of farms in part-time use on the better soils. Agricultural enterprises on part-time farms tend to be considerably larger in the remote and more rural areas. Forty percent of the part-time farmers at the present time are retired or unemployed, while 20 percent are craftsmen or factory operators. In general, part-time farmers constitute a fairly representative cross section of all classes of the population. The average value of part-time farms ranges from more than \$6,000 to less than \$3,000 in different counties of the State. Part-time farm families with outside labor averaged \$738 in wages and \$243 in value of food and fuel produced in 1933.

The most common part-time farm enterprises are dairy, poultry, vegetable, and wood products. These enterprises are found in various combinations which differ among various sections of the State. On the average, dairy and poultry products are the most valuable contributions made by part-time farms to family income and sustenance.

Part-time farming in California.—Dealing with part-time farms serving both as homes for wage earners and as supplementary sources of income or subsistence, which have been well represented in California for many years, the California Station has studied the subject in its many aspects and varying degrees of success, but particularly from the standpoints of selection and set-up of the farm, personal and individual factors, business management, and disposition and use of products. The general conclusion of the station is that—

No doubt part-time farms, when well planned and in the hands of competent operators, have an important place in the agriculture of California. But it requires ability to work at tasks: (a) at a wage or salaried position, and (b) at farming. An essential qualification of a part-time farm operator is that he possess sufficient physical and mental equipment so that he can concentrate upon two tasks, frequently of marked difference in their requirements.

Part-time farming in Ohio.—A survey by the Ohio Station of the agricultural activities of nonagricultural workers residing on small tracts of land in the country showed that their sales of farm products did not cover cash costs connected with the production of crops and livestock products. Evidence was obtained that the standards of living of many individual families with urban employment may be raised by moving to rural homesteads.

The Ohio Station finds that the number of persons who combine rural living with nonagricultural occupation is increasing. The station estimates that in 1934 there were 100,000 rural nonfarm families in Ohio who were obtaining some of this living from the land. A study made by the station of 202 such families living near Columbus showed that the homesteads occupied ranged in size from 1 to 20 acres. The retail value of foodstuffs raised and consumed averaged \$149 per household, while additional food purchased cost \$240. In other words, these families produced only 38 percent of their total food bill. Sales of produce, mostly poultry and vegetables, averaged only \$76 per household.

On over half of the rural homesteads receipts from sale of farm products amounted to less than \$25 and for the whole group were not sufficient to cover the cost of feed for livestock, baby chicks, and other livestock bought and of seed, fertilizer, and hired labor. * * * Families with tracts of 5 acres, a large garden, a cow, a few hogs, and a flock of chickens produced less than 60 percent of their total food budget. This does not correspond with some of the claims that practically all of the family's living can be produced on a small tract of land.

It is not so much the needs of the nonfarm family that determine what they produce as it is their likes and dislikes. Thus, families, the heads of which were employed full time and made satisfactory incomes, produced as large a proportion of their foodstuffs as those employed only part time. Households with low incomes produced only a slightly larger percentage of their food supply than did those in the higher income groups; and those in which both head and homemaker were farm reared were more successful at food production than were those with no previous farm experience.

Comparative size of rural and urban school children.—Comparing the size of 12,913 rural school children and 13,871 urban children between the ages of 6 and 15 years on the basis of weight-height-age data, the Utah Station found that though rural boys were smaller than urban boys of the same age, they conformed more nearly to weight standards for corresponding height, age, and sex. Urban boys and both urban and rural girls were below the weight standards for corresponding height, age, and sex.

Attitudes of rural young people toward farming.—From information obtained by the South Carolina Station from 924 white and 566 Negro high-school seniors in 1932 and 1935, respectively, it appears that a larger percentage of the white than of the Negro youth lived on farms while attending high school. Forty and four-tenths percent of the white and 25 percent of the Negro youth studied were favorable in their attitude to farm life. Sixty-nine and three-tenths percent of the white and 71.2 percent of the Negro youth agreed that farm life had pleasant aspects not incident to city life. Outstanding among the reasons given for leaving the farm were low farm income, frequent lack of modern farm and home equipment, and the belief that cities offer more attractive economic, social, and educational opportunities than the country. The lack of adequate rural educational advantages were instanced more frequently by the Negro than by the white students. Engineering led as the professional choice of the white boys and teaching as that of the white girls. Among the professions, teaching was the first choice of both the Negro boys and girls who planned to attend college. Farming was the first occupational choice of the white boys, and nursing of the white girls who had no expectation of going to college.

Data obtained by the New York (Cornell) Station from 307 young men, 54 percent of whom were farmers' sons and 33 percent sons of skilled or unskilled laborers, showed their interests to be mainly social-recreational or economic-vocational with definite need for vocational guidance. There was a distinct urge toward a skilled trade as a life work but little evidence of a definite plan to give it effect. A preponderating number expressed a preference for rural life and farm work.

Length of occupancy of farms.—The New Hampshire Station has found in a study of occupancy of farms in that State that of 388 farm occupants 21 percent had lived on the farm for less than 2 years. Only 16 percent had lived on the farm for over 30 years.

Age of operators of submarginal farms.—The New Hampshire Station finds little evidence to support the contention that submarginal farms in the back towns of New Hampshire are being operated by old men. A little more than 50 percent of the operators were men under 50 years and only 25 percent of the operators were men over 60 years old. The older men as a whole seemed to be doing as much farming as the younger ones. There were only a few instances in

which occupancy of these farms was a definite step in old-age retirement.

Farm tenancy in North Carolina.—Farm tenancy in North Carolina is, according to the North Carolina Station, largely determined by the character of the agriculture of the State, and it is suggested that attempts to reduce it should begin with a change in the type of farming. Other factors such as custom, human differences, laws, etc., may play a part.

It is conceivable, for instance, that by changing our basic laws of property and contract, we could reduce tenancy without changing our type of agriculture. It is conceivable, also, if not very probable, that a reduction in the amount of farm tenancy might result in a change in the type of agriculture. That is, the fact that our laws make tenancy possible may be a major "cause" of our type of agriculture. * * * However, under existing laws of land ownership, the type of agriculture is the major factor determining tenancy.

Types and trends of agriculture in different farming areas.—For more than a decade the Kansas Station has been assembling information to show the trends in the agriculture of the different type-of-farming areas within the State. In 1934 this work was expanded to include studies of the individual farms in the various type areas. From the data available, the farms in more than 40 typical counties have been sorted according to size and type. The more typical farm organizations in each size group have been determined. Budgets are being set up for the typical organizations determined within each size group. These budgets represent existing conditions on these farms. Following this work, new organizations and new budgets are set up based on the changes which it seems desirable for these farms to make. The budgets permit comparison of the existing and the suggested types of farming from the standpoint of their desirability for the farmers concerned. The suggested organizations are then combined according to their respective importance to determine the effect of the changes proposed on the total production within each type-of-farming area and within the State. It is thought that such information will be highly valuable in agricultural-adjustment programs, in educational work with farmers, and could well form the basis for the entire agricultural extension program of the State.

Crop adjustment in the Big Horn Basin.—A study by the Wyoming Station of the type of farming which has been successful in the Big Horn section shows that sugar beets and beans are the principal cash crops in this section. Beet production, and to some extent the bean production, are supplemented by livestock feeding in the winter. Plans for farm organizations which may be expected to produce a satisfactory family living have been worked out.

Consumer demands and industrial recovery and employment.—A survey made by the Minnesota Station of consumer demands in representative urban centers in Minneapolis has given interesting and valuable information indicating the relationships of industrial recovery and employment in the present agricultural situation. For example, the relation found to exist between income and consumption of dairy products suggests that an increase in income of the low-income group may be expected to increase materially the per-capita fluid milk and butter consumption of that group; in the medium-income group, a light increase in butter and fluid milk and a considerable increase in cream may be expected, while the high-income group probably

will not show much change. In the case of meats, likewise, a striking relationship was found to exist between income and the quantities, kinds, and qualities of meats consumed. Those included in the high-income group were consuming nearly twice as much meat and spending nearly three times as much per person as those in the low-income group.

SAFEGUARDING RURAL HEALTH

Safeguarding rural health through study of the nutritive value and wholesomeness of foods; eradication of diseases such as tuberculosis and infectious abortion (Bang's disease); producing meat of better quality; meat inspection; acquiring and disseminating information regarding better methods of marketing superior products; and drainage of swamps and control of mosquitoes is a growing feature of direct and incidental work of the stations. A few examples of such work recently reported are as follows:

Eradication of poison-ivy and prevention of ivy poisoning.—Poison-ivy, which causes so much human discomfort, the New York State Station says "can usually be eradicated with comparative ease and at little cost", either by grubbing out the plants or by the simpler and cheaper method of spraying with a solution of 3 pounds of common salt in a gallon of soapy water applied on the leaves when full grown, usually early or mid-June. Later applications may be needed if the plants put out new shoots. The station warns that care must be exercised not to get the salt spray on valuable plants or to saturate the soil. With regard to treating ivy poisoning, the station says that thorough and repeated washing of exposed parts with a strong alkaline kitchen or laundry soap is effective, as is the use of potassium permanganate, ferrous sulphate, soda, Epsom salts, and hot water.

Curing of human relapsing fever.—The California Station reports that "the vector of human relapsing fever in the Sierra Nevada Mountains of California has been definitely determined as a new species of tick named *Ornithodoros hermsi* Wheeler." This important discovery was made by the station in cooperation with the Hooper Foundation for Medical Research.

Mosquito control.—There is widespread interest in the problem of mosquito eradication or control. The mosquito is a nuisance and menace to health, comfort, and well-being of both man and beast. With the encouragement of financial support from Federal emergency and recovery funds, the problem is beginning to receive attention on a large scale. A number of the experiment stations have been active in studying the subject for many years and have made important contributions to mosquito control.

Systematic mosquito control has been in progress in Connecticut and New Jersey for many years. The stations in these States have actively participated with the State governments, especially in furnishing information regarding the more technical aspects of the subject. More recently the Delaware Station has undertaken similar work. Conditions affecting the multiplication of mosquitoes have been studied by the Montana Station for several years. The California, Indiana, Iowa, Kansas, Maryland, and New Hampshire Stations, among others, have taken an active interest in the subject.

As a part of its continuous campaign against mosquitoes, the New Jersey Station has developed a mixture of light petroleum oil and

pyrethrum extract emulsified with soap and diluted with 10 to 12 times its bulk of water which has proved to be very effective in killing mosquito larvae in pools and puddles as well as adult mosquitoes on the wing. It quickly destroys all mosquito larvae with which it comes in contact. It is nonpoisonous to higher animals and man. It is not injurious to water plants and is cheap enough to render its use practicable. It has been protected by patent against commercial monopoly, but there is no restriction on its use. Experiments by the station have demonstrated that when applied as a fine mist by means of a sprayer it spreads over the soil and vegetation, to which it clings closely for several hours, acting as a repellent to adult mosquitoes.

B. YOUNGBLOOD.

AGRICULTURAL ENGINEERING

As brought out in the previous sections of this report, the principles of engineering enter in some form into nearly all agricultural and farm home operations and into movements toward the betterment of farm life. A few especially significant examples of work in agricultural engineering in some of its broader economic aspects are recorded here to indicate something of the character and scope of service rendered by the experiment stations by engineering research.

Snow cover irrigation water resources.—Flood prevention and control and the conservation of snow run-off for irrigation purposes now are becoming specialized features of snow surveying. Knowledge of snow depths and rates of melting insure greater accuracy in predicting the run-off of streams, having their headwaters in mountainous sections, than is possible from run-off data alone. Information so obtained is of special value both in the design of spillways for dams and in laying down programs of reservoir construction and operation that will provide adequate flood storage without unnecessary sacrifice of stored water. An outstanding accomplishment of many years research by the Nevada Station is the development of efficient methods of snow surveying and measuring water supplies available from this source for irrigation and related uses, which are finding wide practical application in this country and abroad. Accuracy within 10 percent is usually attainable in forecasting stream flow from mountain snow measurements by these methods. Similarly the water-conservation program of the Utah Station, which is based on snow measurements and water-supply forecasts, is reported to have been indirectly responsible for the saving of approximately 400,000 acre-feet of water during 1934, which in turn saved crops valued at several million dollars.

Rammed earth for farm structures.—Interest in the use of rammed earth in the construction of farm service buildings appears to be increasing. The South Dakota Station, which has taken a leading part in developing the utility and economy of this type of farm construction, has found that colloids in soils are unfavorable for durability of rammed-earth construction. In fact a bare rammed-earth wall will resist weathering in almost a perfect inverse ratio to the colloid content of the soil from which it is made. Since information as to the colloid content of soils is essential to the selection of soils best suited to rammed-earth construction the sta-

tion has studied the relationship of the colloids to the weather resistance of rammed-earth walls. In that connection it has successfully adapted the so-called hydrometer method of quickly determining the colloid content of different soils which offers a satisfactory and practicable basis for selecting soils for this purpose. The station has found that the dividing line between favorable and unfavorable soils for rammed-earth construction is at the point where the soil contains 40 percent of colloids.

Tractive efficiency of the farm tractor.—The use of power in agriculture is a very important factor in present-day crop production. The application of power to farm operations has reduced the labor required in growing several important crops by one-half during the past 30 years. However, the cost of power at present is a large item in producing most agricultural crops and is usually from 25 to 40 percent of the operating costs of production. Efficiency and economy in the use of power therefore have an important influence upon the total production cost. Nearly a third of the primary horsepower used on farms in the United States is supplied by tractors of which the greater number are of the wheel type. Much of the power delivered to the drive wheels of such tractors in the past has been lost by slippage, rolling resistance, and other factors, due largely to improper design, improper operation, or both. The Iowa Station, building upon the experience of several other stations, has determined many of the important fundamental facts involved in securing maximum traction from wheel-type tractors on various soils and thereby taking full advantage of the power available. The maximum tractive efficiency of tractors tested under various conditions was found to vary from 40 percent for soft field conditions to 84 percent for smooth hard sod. The rolling resistance of tractors over tractive surfaces was the principal cause of low efficiency. Various means of increasing tractive efficiency and thereby taking greater advantage of the engine power available in the form of increased draft capacity were developed for different soil conditions. On loose soil of uniform texture increasing the width of the wheel tire by use of an extension rim increased the tractive efficiency. On soil with loose surface but firm subsurface the use of long spade lugs reaching firm soil increased the efficiency over shorter lugs. Five-inch angle lugs mounted on a wheel 42 inches in diameter with a rim 12 inches wide gave higher tractive efficiency than spade lugs on freshly prepared loose soil. Extension angle iron lugs increased the tractive efficiency on loose soil one-fifth to one-fourth. Angle iron lugs extending over wheel rims were advantageous on sticky soil. Increasing the weight on a 12-inch by 42-inch traction wheel about 28 percent when equipped with spade lugs increased the drawbar pull appreciably. This increase in drawbar pull was approximately doubled when the wheel was equipped with extension rims and angle lugs. The tractive efficiency of steel drive wheels was progressively increased by increasing the diameter from 38 to 42 inches. The rolling resistance of wheel tractors was materially reduced by low-pressure pneumatic tires and the maximum tractive efficiency was increased progressively by decreasing the inflation pressure from 20 to 8 pounds per square inch. The Illinois Station showed further in practical field tests that the per-acre cost of operating wheel tractors

may be reduced substantially by the use of low-pressure pneumatic tires and the work capacity of the tractor increased.

Use of electricity in agriculture.—As many as 28 of the State stations have engaged in research on the utilization of electricity in agriculture during the past 10 years, not only for conventional household uses but for many production operations. This has entailed especially the development and adaptation of electric equipment to farm requirements and has resulted in over 200 practical applications of electricity to agriculture and some 2,250,000 rural users of electricity, of which a third are actual farmers. There has thus been a marked increase in the use of electrical energy for stationary farm production operations, including feed grinding, poultry incubating and brooding, irrigation pumping, wood sawing, hay hoisting, dairy equipment and product sterilization, milking, cream separation, grain threshing, greenhouse and hotbed heating, crop processing, and many others. For example, the Indiana and California Stations have been successful in the development of electrical equipment for the attraction and killing or trapping of economically important insects such as codling moth, grape leafhopper, and several others. Several State stations, including those in Indiana, New York (Cornell), California, Maryland, Missouri, Ohio, Illinois, and others, have developed electrical hotbed-heating apparatus which has not only yielded a profit to vegetable growers but in some cases has been adapted for the growing of disease-free plants. The Pennsylvania, California, Michigan, and several other stations have successfully developed the principles of efficient and economical chick brooders which encompass the features of optimum temperature distribution, maximum chick comfort, and minimum death losses.

Electric heat for propagating benches.—Use of electricity as a source of heat in propagating beds is increasing. The California Station has attempted to determine the connected load necessary in a propagating bed under different conditions, and finds that whereas the manufacturers' recommendation is 6.66 watts per foot, if the cable is not injured by this connected load when surrounded with air or dry sand it will not be injured by double that amount when surrounded with wet sand.

Farm and rural community buildings.—The need for low-cost serviceable farm and rural community buildings has been recognized by practically all the State stations. The Arkansas Station in particular has given considerable attention to plans for farm and community buildings. Plans have been published, including materials and costs, for rural community structures suitable for canning, recreation, and community meeting, which are based on a careful study of country needs and ability to build such structures. Also new house plans, material lists, and cost estimates have been prepared for 20 houses, graded in size and cost to meet the range of farm housing needs in the State.

Improvements of draintile.—The tiling of land has become an important factor in the conservation, development, and use of land and water resources for agricultural purposes. Performance of the function of moisture regulation alone has required the installation of many thousands of miles of tile lines in the northern United States which in the aggregate represents a large investment. Constant experimentation has been under way at several of the State stations, therefore, to develop tile materials of minimum cost and maximum

durability in view of the destructive agencies present in soils such as acids, alkali salts, freezing and thawing stresses, and others. Both the Minnesota and Wisconsin Stations have been specially active in this work. The Minnesota Station, cooperating with the Bureau of Agricultural Engineering of the Department of Agriculture, has shown that curing portland cement concrete drain tile in steam at temperatures between 212° and 350° F. increases the resistance of the tile to the destructive action of sodium sulphate almost to the point of immunity. It also very greatly increases the resistance to attack by magnesium sulphate. These two soil alkalies are common to subsoils of western Minnesota and the States farther west and have been peculiarly destructive to concrete-tile systems. More recently the Minnesota Station has found that by small admixtures of calcium chloride and curing at temperatures between 100° and 150° the sulphate resistance of concrete tile can be very appreciably increased at a practically negligible increase in cost. This knowledge of improved processes for concrete tile manufacture is being used by manufacturers with the result of greatly lengthening the life of drainage systems constructed of concrete tile. The Minnesota Station also has developed an absorption test of clay tile which has been adopted by some 23 manufacturing plants in Iowa and Minnesota and which has resulted in a general improvement in the quality of clay tile sold.

R. W. TRULLINGER.

EXPERIMENT STATIONS IN ALASKA, HAWAII, AND PUERTO RICO

The status of the experiment stations in Alaska, Hawaii, and Puerto Rico remained substantially the same as during the previous year except for some extension of their activities.

ALASKA STATION

The Alaska Station, under the jurisdiction of the Alaska Agricultural College and School of Mines, again received the annual appropriation of \$15,000 provided by extension of the Hatch Act to the Territory in 1929. The station has much the same status as the State experiment stations but operates on budgets and projects approved by the Office of Experiment Stations.

The station is concerned mainly with possibilities of plant and animal production and dairying in the district around Fairbanks, in the Tanana Valley, and at Matanuska, in the Matanuska Valley. It continued to disseminate information regarding agricultural possibilities, suitable crops and cultural practices, and animal production and dairying in Alaska for which there is a considerable demand, particularly in connection with Government land settlement in the Matanuska Valley.

HAWAII STATION

The work of the Federal experiment station of Hawaii associated with the University of Hawaii at Honolulu was not changed in any essential particular, the main purpose being, as heretofore, to develop a more diversified and self-sustaining agriculture in the island. Helpful relations with the experiment stations maintained by the sugar and pineapple industries of the island were continued, and the work of the station was extended and diversified. Representative

examples of the work of the year were further perfection and extension of the Mitscherlich soil-fertility test; grading, curing, and storing macadamia nuts; improvements in coffee culture; utilization of coffee pulp; further study and extension of use of range and pasture grasses and forage crops; study of the nutritive value of Hawaiian food products; investigation of effect of light on egg production and of housing of poultry; improvement of potato culture; determination of the feeding value of molasses; and miscellaneous studies of tropical fruits.

The income of the station for the fiscal year 1935 was \$91,977 as compared with \$86,270 for the previous year. The station had \$15,000 from the Hatch fund, \$13,000 from the Adams fund, \$32,977 from direct appropriation through the Department of Agriculture, and \$31,000 from territorial and university sources.

The publications of the station during the year were Bulletin 72, Napier Grass (*Pennisetum purpureum*): A Pasture and Green Fodder Crop for Hawaii, by C. P. Wilsie and M. Takahashi; Report of the Hawaii Agricultural Experiment Station, 1934; Journal of Agricultural Research papers, The Nutritive Value of Green Immature Soybeans, by Carey D. Miller and Ruth C. Robbins, and Natural Crossing in the Pigeonpea, by C. P. Wilsie and Makoto Takahashi; Bulletin 73, Cane Molasses as a Feed for Dairy Cows, by L. A. Henke; Bulletin 75, Coffee Cultural Practices in the Kona District of Hawaii, by J. C. Ripperton, Y. B. Goto, and R. K. Pahau; and Circular 10, Turkey Management in Hawaii, by C. M. Bice.

PUERTO RICO STATION

The Puerto Rico Experiment Station continued its successful efforts to correlate the work of the station at Mayaguez with that of the Insular Government Station associated with the College of Agriculture of the University of Puerto Rico, and to develop the station as an outpost for certain lines of tropical research of special interest to mainland agriculture. The leading permanent features of the work of the station at Mayaguez, as in previous years, were development and introduction of improved sugarcane varieties, coffee fertilizing and cultural practices, control of animal parasites, and general service in aid of the establishment of a more self-sustaining agriculture in the island. Some of the more recent developments in work of the station include study of rainfall distribution in the island; production and utilization of bamboos; further improvement of a new tropical sweet corn; and growing winter vegetables especially for the mainland markets.

The Federal appropriation for this station for the fiscal year was \$35,959 as compared with \$41,860 for the previous year. In addition the station received from the Insular Government and other sources \$11,328.

Special effort was made as in previous years to develop and carry forward a coordinated research program in which all of the research agencies of Puerto Rico participated. A coordinating committee was created and functioned actively. This committee included the dean of the College of Agriculture of the University of Puerto Rico, the director of the Federal station at Mayaguez, the director of the Insular station at Rio Piedras, and the commissioner of agriculture of the island.

Near the end of the year allotment of \$113,000 from sugar-processing-tax funds was assigned to the Federal station at Mayaguez. Very gratifying progress was made in organizing a program of research integrated with the emergency activities and supplementing regular research work in the interest of rehabilitating agriculture and improving standards of living in the island.

The publications of the station during the year were Bulletin 36, Parasites and Parasitic Diseases of Cattle in Puerto Rico, by H. L. Van Volkenberg; and Report of the Puerto Rico Agricultural Experiment Station, 1934.

MAJOR CHANGES IN PERSONNEL

Changes in major positions at the experiment stations during the fiscal year ended June 30, 1935, were approximately 43, this being a somewhat lower figure than for the preceding period. Seven deaths were reported.

Directorship changes were as follows: O. C. Magistad was appointed director of the Hawaii Station succeeding J. M. Westgate, who relinquished these duties to become consultant in tropical agriculture for the station. H. L. Walster, dean of the school of agriculture at the North Dakota College, succeeded P. F. Trowbridge, who resigned the directorship of the station July 1, 1934. The South Carolina Station reported the selection of R. A. McGinty, of Oklahoma, to act as director during the absence of H. W. Barre, who accepted a temporary position in the United States Department of Agriculture. P. V. Cardon resigned as director of the Utah Station, effective June 30, 1935, to come to the Department. Pending the appointment of a new director an advisory committee was formed and W. P. Thomas, agricultural economist for the station, was named as chairman.

PUBLICATIONS

The stations issued 864 publications of the regular series during the past year as compared with 842 the previous year. Classified by scientific subjects these publications fall into the following groups: Meteorology, 14; soils and fertilizers, 41; field crops, 89; horticulture, 94; forestry, 7; plant diseases, 51; entomology and zoology, 87; foods and human nutrition, 21; rural-home management, 12; animal production, 88; dairying, 53; diseases of livestock, 37; agricultural engineering, 33; economics and sociology, 140; and annual reports and miscellaneous publications, 97. Classified by major objectives of the work, as indicated on page 9, the publications, exclusive of certain purely regulatory and service publications, may be grouped approximately as follows: Improvement in crop production and products, 417; improvement in animal production and products, 200; and improvement in rural economic and social conditions, 180.

In addition to their regular series of publications, the stations contributed 1,778 articles reporting or based on their work to 69 outside technical or scientific journals, and 30 of the stations contributed or collaborated in 69 articles published in the Journal of Agricultural Research. The published output of the stations as

measured by these figures was substantially the same as in the previous year.

The amount of station funds expended for publications was \$253,926 as compared with \$246,696 the previous year. While this was not a large increase, it was in significant contrast to the shrinkages of the past few years.

The Office of Experiment Stations continued to prepare for publication monthly, in *Agricultural Library Notes*, its list of scientific and technical articles published by the stations in outside journals. It also extended its indexed list of the regular station bulletins, completing a seventh supplement covering the calendar years 1933 and 1934.

Feeling the need of reaching the general reader more effectively in popularizing and making more widely useful the results of their research, several of the stations have undertaken recently to issue new series of popular publications. *Farm Research*, a quarterly magazine for farmers, begun in October 1934 by the New York State Station, is an outstanding example of such publications. This periodical is intended to keep farmers and others posted on new developments in the research work of the station which may be of interest to them.

Little Stories of Florida Agriculture, begun in February 1935, is another example of new efforts in this direction. A representative number of this series of leaflets dealt in a nontechnical way with some practical aspects of the food and health value of Florida-grown fruits and vegetables, particularly as to their iodine content, and with valuable byproducts, particularly pectin, which may be obtained from citrus waste, such as orange and grapefruit peel.

Many other examples of efforts to popularize results of station work and make them more practically useful might be named. At the same time the stations have had difficulty in finding adequate means of publication of the increasing volume of the more technical results of their work.

Monthly progress reports were distributed in mimeographed form by the New Jersey Station, primarily for the use of their specialists. These reports not only keep the director in close touch with what is going on in the different departments of the station but inform these departments as to each other's work and call attention to current developments of practical value.

Many other evidences of a purpose to make the results of station investigations more readily understood and applied could be cited.

LIBRARY FACILITIES AND SERVICES

Library facilities were increased at the Connecticut (State) Station by the addition of approximately 5,085 volumes, at the Florida Station of 2,324 volumes and approximately 9,254 pamphlets, and at the Georgia Station by 423 bound volumes. The Florida Station added 7,731 cards to its catalog, and the Georgia Station about 6,000 cards. Loss of the reading room of the station library in Florida caused considerable congestion and inconvenience. In New Jersey also physical facilities were greatly taxed to meet the needs of employees on projects sponsored by the Civil Works Administration, despite the fact that two C. W. A. workers were added to the staff to assist in the routine work and extend the cataloging.

INCOME, EXPENDITURES, AND OTHER STATISTICS, 1935

By J. I. SCHULTE

The following tables give detailed data regarding (1) personnel, publications, and mailing lists of the experiment stations; (2) revenues and additions to equipment; (3) expenditures from the Hatch, Adams, and Purnell funds; (4) expenditures from the supplementary funds; and (5) total disbursements from the United States Treasury under the Hatch, Adams, and Purnell Acts from their passage to the end of the fiscal year, June 30, 1935.

Station	Date of organization under Hatch act	Persons on staff	Teachers on staff	Persons on staff assisting in extension work	Publications during fiscal year		Names on mailing list
					Number	Pages	
Alabama	Feb. 24, 1888	55	21		21	240	3, 200
Alaska	July 1, 1931	2	1		1	39	273
Arizona	July 1, 1889	46	29		52	794	4, 937
Arkansas	Apr. 2, 1888	48	30		30	647	6, 105
California	March 1888	219	128	137	46	2, 637	11, 910
Colorado	Feb. 29, 1888	65	30	5	27	779	750
Connecticut (State)	May 18, 1887	47			51	1, 095	14, 281
Connecticut (Storrs)	do	31	11	5	7	302	10, 700
Delaware	Feb. 21, 1888	23	8	5	8	216	8, 000
Florida	March 1888	79	9	5	64	1, 536	18, 000
Georgia	July 1, 1889	31			15	352	6, 500
Hawaii	July 1, 1929	15	12	2	16	159	1, 247
Idaho	Feb. 26, 1892	54	26	7	22	286	16, 575
Illinois	Mar. 21, 1888	120	74	11	102	2, 924	25, 199
Indiana	January 1888	110	24		148	1, 272	39, 010
Iowa	Feb. 17, 1888	140	67	19	106	2, 310	25, 018
Kansas	Feb. 8, 1888	115	85		121	312	12, 000
Kentucky	April 1888	73	25	5	27	420	4, 858
Louisiana	Apr. 5, 1887	51	7		18	344	880
Maine	Oct. 1, 1887	38	5	5	23	659	14, 500
Maryland	Apr. 1888	62	26	6	14	365	18, 000
Massachusetts	Mar. 2, 1888	78	4	5	52	651	1, 600
Michigan	Feb. 26, 1888	126	71	6	45	1, 389	13, 034
Minnesota	—, 1888	161	135	7	219	1, 383	5, 000
Mississippi	Jan. 27, 1888	53	20	2	8	155	10, 000
Missouri	January 1888	78	54	2	132	364	6, 000
Montana	July 1, 1893	45	14	6	21	613	5, 000
Nebraska	June 13, 1887	61	21		27	370	5, 000
Nevada	Dec. 1887	18	2		19	267	4, 500
New Hampshire	Aug. 4, 1887	51	25	8	15	240	8, 000
New Jersey (College)	Apr. 26, 1888	37	51	32	152	708	12, 000
New Jersey (State)		176					
New Mexico	Dec. 14, 1889	28	15	1	49	366	12, 000
New York (Cornell)	April 1888	147	86		258	1, 707	76, 050
New York (State)	do	72			84	719	12, 000
North Carolina	Mar. 7, 1887	43	12	1	7	244	11, 260
North Dakota	March 1890	55	22	3	12	237	15, 000
Ohio	Apr. 2, 1888	114	32	7	77	999	34, 650
Oklahoma	Oct. 27, 1890	66	40		61	846	6, 000
Oregon	July 1888	99	34	2	43	402	1, 760
Pennsylvania	June 30, 1887	132	92		61	590	30, 530
Puerto Rico (Mayaguez)		7			2	50	1, 900
Puerto Rico (Rio Piedras)	July 1, 1934	29			6	615	2, 074
Rhode Island	July 30, 1888	29	12	6	16	256	3, 500
South Carolina	January 1888	36	10	1	17	522	6, 000
South Dakota	Mar. 13, 1887	37	28	2	20	128	9, 284
Tennessee	Aug. 4, 1887	35	7		20	205	19, 321
Texas	Apr. 3, 1889	116			66	1, 283	80, 669
Utah	Nov. 16, 1889	40	29	5	51	788	10, 000
Vermont	Feb. 28, 1888	31	10	1	21	702	3, 850
Virginia	March 1888	51	15	4	34	240	12, 000
Washington	May 22, 1891	62	29		34	580	1, 747
West Virginia	June 11, 1888	49	28	8	21	389	14, 000
Wisconsin	July 1, 1887	135	81	49	8	411	58, 000
Wyoming	Mar. 1, 1891	37	19	1	44	516	8, 000
Total		3, 658	1, 616	366	2, 621	36, 653	741, 672

¹ Including 15 who are on college station staff but not included in total.

TABLE 5.—Income, and expenditures

Station	Income					
	Federal			State	Balance from previous year ¹	Fees
	Hatch fund	Adams fund	Purnell fund			
Alabama.....	\$15,000	\$15,000	\$60,000	\$60,272.11	\$67,945.56	\$38,540.85
Alaska.....	15,000	.....	.....	3,000.00	1,030.18	5,168.25
Arizona.....	15,000	15,000	60,000	79,569.64	4,551.92	2,757.19
Arkansas.....	15,000	15,000	60,000	50,824.42	1,693.47	21,894.01
California.....	15,000	15,000	60,000	759,978.75	15,282.41	38,604.16
Colorado.....	15,000	15,000	60,000	82,933.26	24,048.78	33,045.48
Connecticut (State).....	7,500	7,500	30,000	186,214.07	.....	\$23,000.00
Connecticut (Storrs).....	7,500	7,500	30,000	34,475.65	.....	4,101.77
Delaware ²	15,000	15,000	60,000	18,000.00	4,703.85	13,234.35
Florida.....	15,000	15,000	60,000	301,322.50	30,327.35	25,995.14
Georgia.....	15,000	15,000	60,000	9,250.00	8,522.55	24,891.48
Hawaii ³	15,000	13,000	.....	.....	.....	14,042.41
Idaho.....	15,000	15,000	60,000	22,418.59	1,335.29	4,106.98
Illinois ²	15,000	15,000	60,000	333,681.63	.....	61,893.15
Indiana.....	15,000	15,000	60,000	230,000.00	205,690.95	92,397.41
Iowa.....	15,000	15,000	60,000	192,390.75	6,207.56	31,756.95
Kansas.....	15,000	15,000	60,000	84,804.96	32,532.09	51,131.60
Kentucky.....	15,000	15,000	60,000	104,498.46	15,892.26	40,900.92
Louisiana.....	15,000	15,000	60,000	51,400.00	2,468.10	22,520.97
Maine.....	15,000	15,000	60,000	28,127.94	.....	7,105.33
Maryland.....	15,000	15,000	60,000	51,756.73	10,021.73	12,769.47
Massachusetts.....	15,000	15,000	60,000	165,477.88	.....	4,823.55
Michigan.....	15,000	15,000	60,000	248,644.41	.....	22,700.73
Minnesota.....	15,000	15,000	60,000	332,873.41	.....	40,393.52
Mississippi.....	15,000	15,000	60,000	79,999.96	28,300.41	51,868.58
Missouri.....	15,000	15,000	60,000	32,238.32	30,965.24	25,476.97
Montana.....	15,000	15,000	60,000	71,573.89	10,083.89	57,959.96
Nebraska.....	15,000	15,000	60,000	119,506.35	.....	49,021.47
Nevada.....	15,000	15,000	60,000	3,104.51	3,396.75	5,494.77
New Hampshire.....	15,000	15,000	60,000	5,458.00	15,225.63	2,656.16
New Jersey (College).....	15,000	15,000	60,000	.....	.....	.....
New Jersey (State).....	.....	.....	.....	351,770.00	.....	60,840.24
New Mexico.....	15,000	15,000	60,000	5,400.00	35,175.61	15,673.73
New York (Cornell).....	13,500	13,500	54,000	508,930.63	.....	71,375.09
New York (State) ²	1,500	1,500	6,000	342,079.45	164.57	15,288.89
North Carolina.....	15,000	15,000	60,000	68,323.61	1,809.99	39,640.94
North Dakota.....	15,000	15,000	60,000	.....	19,122.17	44,251.18
Ohio.....	15,000	15,000	60,000	408,400.00	331,187.03	58,771.89
Oklahoma.....	15,000	15,000	60,000	59,365.13	10,847.88	19,118.01
Oregon.....	15,000	15,000	60,000	89,037.58	38,261.16	39,105.54
Pennsylvania.....	15,000	15,000	60,000	119,074.31	4,568.55	43,488.06
Puerto Rico (Mayaguez) ³.....	.....	.....	.....	.....	.....	.....
Puerto Rico (Rio Piedras).....	15,000	10,000	.....	111,328.25	.....	.....
Rhode Island.....	15,000	15,000	60,000	.....	892.91	7,004.79
South Carolina.....	15,000	15,000	60,000	47,850.00	11,305.28	73,433.81
South Dakota.....	15,000	15,000	60,000	16,560.00	8,062.94	11,364.82
Tennessee.....	15,000	15,000	60,000	23,479.67	.....	13,066.07
Texas.....	15,000	15,000	60,000	245,261.00	69,750.94	93,582.86
Utah.....	15,000	15,000	60,000	35,500.00	12,251.11	18,105.50
Vermont.....	15,000	15,000	60,000	.....	637.86	470.21
Virginia.....	15,000	15,000	60,000	80,275.00	63.24	8,574.07
Washington.....	15,000	15,000	60,000	79,055.87	.....	32,530.81
West Virginia ²	15,000	15,000	60,000	41,750.00	.....	39,137.84
Wisconsin.....	15,000	15,000	60,000	267,328.89	.....	56,928.19
Wyoming.....	15,000	15,000	60,000	78,210.85	24,636.57	17,196.11
Total.....	765,000	743,000	2,880,000	6,722,776.43	1,089,023.78	1,532,339.30

¹ Not including balances from Federal funds.² Including unexpended balances—Delaware, Purnell \$1,286.78; Illinois, Purnell \$1,392.05; New York State, Adams \$275.83; West Virginia, Hatch \$164.26, Adams \$845.27, Purnell \$57.11.³ Support from direct appropriations to the U. S. Department of Agriculture given under Miscellaneous: Hawaii, \$32,977, and Puerto Rico (Mayaguez), \$35,959.

for additions to equipment, 1935

Income—Continued		Expenditures for additions to equipment						
Miscellaneous	Total	Buildings	Library	Apparatus	Farm implements	Livestock	Miscellaneous	Total
\$9,750.31	\$266,508.83	\$411.50	\$747.02	\$2,429.16	\$1,964.98	\$332.00	\$1,239.38	\$7,124.04
	24,198.43	887.66	12.00	45.05	909.92	80.00	50.66	1,985.29
	176,878.75	353.03		2,491.37	241.22	19.24	1,461.31	4,566.17
750.00	165,161.90	14,300.00	956.79	6,682.43	4,968.96	632.76	772.07	28,313.01
63,227.90	967,098.22	16,122.54	7,000.00	5,227.37	5,227.38	5,227.37	5,227.38	44,032.04
	230,027.52	5,095.00	269.00	3,386.00	7,529.00	1,280.00	34,185.00	51,744.00
7,600.00	261,214.07		1,309.86	817.15	5,267.87		926.94	8,321.82
2,543.24	87,491.10		975.88	1,139.54	74.90	101.40	174.20	2,465.92
	125,938.20	1,519.95	1,247.18	1,549.11	2,112.28	475.00	1,280.39	8,183.91
	447,644.99	18,533.18	2,264.44	3,605.90	11,534.16	1,511.67	2,698.41	40,147.76
	132,664.03	7,100.00	1,207.70	392.59	2,500.00	2,000.00		13,200.29
43,001.54	85,043.95		201.76	1,096.19	164.14	579.84	544.71	2,586.64
	117,860.86		375.00	5,000.00	865.00	300.00	3,135.00	9,675.00
29,469.26	515,044.04	537.29	126.94	2,687.88		327.40	19,872.56	23,552.07
81,460.46	824,003.48	29,666.01	1,998.45	6,113.66	2,775.50	4,146.87	2,808.79	47,509.28
16,536.69	336,891.95	6,760.00		4,526.69	603.37	3,126.98	22,850.00	37,807.04
1,889.00	260,357.65	6,181.71	95.70	6,123.27	10,366.95	2,017.53	1,002.52	25,787.68
	342,075.44	7,737.80	641.91	5,337.79		1,365.00	1,311.03	16,393.53
7,740.97	198,618.96	180.01	53.50	2,404.42	4,847.77	1,158.05	765.06	9,408.81
10,351.70	139,594.01	853.08	903.28	1,248.25	1,291.56	980.95	626.05	5,903.17
4,763.55	174,899.63	3,110.09	439.20	2,612.67	2,315.80	718.64	815.74	10,112.14
	322,394.72	8,251.91	689.10	2,819.69	2,411.00	483.41	1,644.72	16,299.83
	361,345.14	3,348.00	1,220.00	3,756.00	2,108.00	80.00	1,896.00	12,408.00
45,607.23	509,462.61	21,607.93	1,334.52	2,608.25	5,306.50	3,600.16	1,957.65	36,415.01
5,852.52	256,081.47	19,302.55	204.80	649.60	14,168.64	11,013.22	1,872.21	47,211.02
13,363.28	218,094.62	50.75	288.44	3,926.85	6,060.41	3,353.06		13,679.51
	229,617.74	4,200.00	400.00	835.00	975.00	675.00		7,085.00
	258,527.82	4,732.75	270.91	7,394.99	1,927.20	8,194.39	83,772.02	106,292.26
	161,996.03	2,901.83	745.76	150.00	710.54	25.00	4,672.84	9,205.97
42,384.01	155,723.80	6,498.40	659.60	2,103.70	1,128.13	248.44	1,551.28	12,189.55
	90,000.00							
4,804.27	463,018.16		935.30	2,737.54	800.00	293.66		4,766.50
	146,249.34	2,010.48	469.24	895.24	1,005.18		2,023.10	6,403.24
	661,305.72	4,438.44	2,603.61	25,443.64	13,308.22	1,783.47	4,704.84	52,282.22
	366,532.91		1,350.30	4,517.06	3,731.04		1,795.10	11,393.50
15,138.31	214,912.85	72,959.22	913.21	2,683.04	4,812.70	3,153.85	4,378.35	88,900.37
20,825.29	174,418.64	1,632.08	269.69	300.75	155.12	3,561.25	204.00	6,122.89
6,045.63	894,404.55	18,857.72	925.67	1,015.28	7,035.91	4,680.68	919.20	33,434.46
2,434.94	229,430.39	4,398.73	1,108.42	1,441.63	419.50	1,785.04	5,008.39	14,161.71
11,206.69	295,934.92	294.57	321.52	2,268.44	3,832.09	4,482.22	3,037.33	14,236.17
	257,130.92		279.00	1,921.13	2,000.06		355.73	4,555.92
35,959.00	35,959.00							
	136,328.25		93.92	262.57	322.04	265.00	3,408.82	4,352.35
	97,897.70	1,500.00	487.00	1,223.00	1,450.00	42.00	32.00	4,734.00
	222,589.09	6,552.48	1,257.33	12,912.54	8,751.41	1,899.44	15.21	31,388.41
3,229.98	129,217.74		300.00	475.00	225.00			1,000.00
	126,545.74	4,415.00	960.65	571.08	3,062.38	7,000.00	3,539.39	19,548.50
122,831.01	621,425.81	4,662.78	1,448.66	7,805.80	5,197.80	2,494.10	473.73	22,082.87
800.00	156,656.61	3,459.20	784.60	1,581.85	97.58	812.24	651.60	7,387.07
	113,351.18	2,263.53	268.40	2,051.09	7.35	100.00		4,690.37
	178,912.31	216.01	872.06	1,861.84	975.87		1,425.00	5,350.78
84,271.01	285,857.69	3,363.26	1,384.06	1,246.25	1,911.63	4,232.56	837.06	12,974.82
500.00	171,387.84		221.04	1,384.59	7,335.63	2,403.26		11,344.52
86,039.01	500,296.09	578.14	2,093.77	4,667.53	2,967.52	4,026.11	822.25	15,155.32
	210,043.53	17,737.00	500.00	817.60	5,479.18	1,439.56	611.98	26,585.32
779,776.80	15,072,261.84	339,521.61	46,486.19	169,245.06	175,239.39	98,507.82	233,357.00	1,662,357.07

TABLE 6.—*Expenditures from United States appropriations received under*

Station	Amount of appropriation	Expenditures							
		Salaries	Labor	Publications	Postage and stationery	Freight and express	Heat, light, water, and power	Chemical supplies	Seeds, plants, and sundry supplies
Alabama.....	\$15,000	\$11,941.92	\$1,428.98	\$252.13	\$156.84	\$37.18	\$76.00	\$68.34	\$169.61
Alaska.....	15,000	4,489.79	5,047.57	228.50	149.15	940.16	1,141.71	37.05	305.86
Arizona.....	15,000	14,766.54	—	—	233.46	—	—	—	—
Arkansas.....	15,000	6,801.63	2,226.77	448.11	303.57	69.19	257.71	275.83	796.95
California.....	15,000	15,000.00	—	—	—	—	—	—	—
Colorado.....	15,000	14,944.00	—	—	—	—	—	—	—
Connecticut (State).....	7,500	7,500.00	—	—	—	—	—	—	—
Connecticut (Storrs).....	7,500	7,500.00	—	—	—	—	—	—	—
Delaware.....	15,000	8,551.02	1,727.03	866.83	1,358.40	15.28	373.04	481.85	125.51
Florida.....	15,000	15,000.00	—	—	—	—	—	—	—
Georgia.....	15,000	8,180.00	2,274.65	1,196.36	666.70	53.87	504.19	64.31	530.92
Hawaii.....	15,000	7,322.35	3,327.98	731.12	20.70	25.13	—	344.78	103.10
Idaho.....	15,000	7,605.89	3,739.04	1,317.89	948.83	21.35	95.51	149.21	128.09
Illinois.....	15,000	14,210.32	286.96	193.78	—	.71	—	—	—
Indiana.....	15,000	15,000.00	—	—	—	—	—	—	—
Iowa.....	15,000	14,731.78	130.49	—	61.53	.15	—	—	49.85
Kansas.....	15,000	9,700.00	4,336.61	15.67	70.88	—	—	147.72	102.96
Kentucky.....	15,000	14,448.28	—	362.90	—	—	—	—	—
Louisiana.....	15,000	8,742.25	3,652.68	1,285.27	168.46	1.59	63.81	9.14	350.59
Maine.....	15,000	8,562.33	1,191.84	7.50	518.08	73.90	1,686.30	304.34	304.20
Maryland.....	15,000	12,976.79	1,201.15	110.76	4.24	4.00	—	56.65	141.89
Massachusetts.....	15,000	13,938.52	—	—	—	—	—	—	9.65
Michigan.....	15,000	15,000.00	—	—	—	—	—	—	—
Minnesota.....	15,000	13,785.66	225.00	—	—	—	—	174.50	244.10
Mississippi.....	15,000	8,846.46	1,390.19	—	234.38	87.62	463.97	12.53	526.34
Missouri.....	15,000	5,073.16	3,088.94	2,039.40	568.24	141.56	44.14	340.42	243.95
Montana.....	15,000	7,874.27	905.88	1,460.72	332.08	11.40	—	50.53	688.83
Nebraska.....	15,000	15,000.00	—	—	—	—	—	—	—
Nevada.....	15,000	10,477.50	41.10	697.15	935.43	9.42	287.49	4.91	484.74
New Hampshire.....	15,000	9,523.96	882.41	588.44	1,182.48	326.68	700.22	108.17	233.32
New Jersey.....	15,000	10,729.41	633.88	84.14	236.91	—	46.61	378.76	163.44
New Mexico.....	15,000	7,553.86	4,088.46	1,199.90	187.04	33.66	288.69	190.90	300.61
New York (Cornell).....	13,500	9,010.20	2,866.83	—	34.18	—	—	615.66	129.58
New York (State).....	1,500	1,376.80	—	—	—	—	—	—	123.20
North Carolina.....	15,000	11,711.86	343.36	189.04	398.12	—	—	190.70	100.67
North Dakota.....	15,000	7,896.67	6,695.06	9.65	18.70	—	9.60	22.60	1.60
Ohio.....	15,000	7,595.41	—	263.52	330.70	—	1,943.44	513.96	293.14
Oklahoma.....	15,000	5,863.91	4,179.08	42.00	208.87	160.56	—	390.87	1,006.69
Oregon.....	15,000	8,107.90	4,371.73	506.00	44.31	10.72	92.40	12.05	100.32
Pennsylvania.....	15,000	12,503.00	1,343.27	968.23	—	5.20	—	2.70	54.37
Puerto Rico.....	15,000	10,754.16	929.15	629.53	313.47	6.02	—	15.51	15.88
Rhode Island.....	15,000	7,186.57	3,887.85	565.90	457.36	67.95	358.55	152.46	407.70
South Carolina.....	15,000	8,104.96	2,120.34	916.66	753.46	15.64	—	50.25	588.56
South Dakota.....	15,000	7,790.00	2,370.59	1,943.07	230.42	12.97	11.53	93.50	266.88
Tennessee.....	15,000	10,002.00	2,696.87	907.20	714.29	10.16	25.39	26.65	92.01
Texas.....	15,000	10,696.88	1,448.77	—	759.86	.67	—	4.81	7.70
Utah.....	15,000	7,828.36	2,660.10	1,109.59	35.09	31.43	8.75	208.75	438.43
Vermont.....	15,000	8,296.48	879.76	2,549.78	393.60	19.10	892.25	262.22	164.25
Virginia.....	15,000	8,391.93	4,426.86	252.78	630.71	20.20	203.76	124.08	268.58
Washington.....	15,000	9,178.78	1,518.79	1,584.65	188.03	—	—	408.09	158.38
West Virginia ¹	15,000	7,580.00	2,436.62	863.00	43.93	6.00	83.95	223.16	447.93
Wisconsin.....	15,000	12,961.32	1,480.46	—	—	—	—	95.96	—
Wyoming.....	15,000	4,777.47	5,672.97	203.59	693.55	65.27	695.06	266.22	475.32
Total.....	765,000	523,392.35	94,156.12	26,590.76	14,586.05	2,284.74	10,354.07	6,880.14	11,145.70

¹ Including balance of appropriation from previous year \$164.26.

the act of Mar. 2, 1887 (Hatch Act), for the year ended June 30, 1935

Expenditures—Continued										
Ferti- lizers	Feed- ing stuffs	Library	Tools, imple- ments, and ma- chinery	Furni- ture and fix- tures	Scien- tific ap- paratus	Live- stock	Travel expenses	Contin- gent ex- penses	Build- ings and land	Balance
\$164.32 117.57	\$53.50 318.15	\$366.10 12.00	\$32.91 1,185.87	\$78.38 9.00	\$24.75	\$65.00 80.00	\$67.15 79.95	\$41.64 143.11	\$689.81	
264.05	2,214.58		229.34	6.00	110.97		672.31	9.20	313.79	
							56.00			
93.65		933.28	64.61	173.05	10.50		200.35	7.00	18.55	
19.25 35.20	134.85 2,083.12	62.18	266.38 433.67	44.29 41.23 51.01 34.00	27.23 411.70 155.07	80.00	899.88 417.44 330.01	35.67 56.15 24.43	39.27	
		2.55								\$271.68
		3.70	46.84		1.00 22.11		25.20 553.51 188.82			
40.20 6.67 61.79	2.70 372.13 42.00	710.95	173.14 75.51	13.89	134.61 126.80	0.06 34.85	501.62 871.59 212.10 301.83	8.49 41.83	89.48 61.83 750.00	
	172.35	6.50	202.60 1,811.43	573.87			239.14 514.54		129.00 344.80	
18.37	1,731.36 2,699.99	119.72 414.47	395.88 45.75	135.81 150.57	155.08 122.46	176.15	294.77 210.42	15.02 17.00	416.05 32.63	
	155.39	52.57	96.17	246.78	203.50	39.60	403.29	115.25	749.71	
89.26 563.22	360.00	516.92 308.91 11.26	31.28 106.28 377.64 8.70	430.29 252.72 267.55	288.70 91.03 791.85		367.54 469.47 182.20	19.03 25.00 37.79 43.00	352.55 189.41	
62.34		8.05 6.00	559.74 36.03	316.77 3.00	39.30		1,080.05 292.13		8.96	
292.77	2,593.15		811.86	319.50	42.55					
	1,231.71	35.61	576.30	89.99	145.30	496.05	559.23	1.50	12.33	
100.33 113.23	10.00	5.53	730.31	277.33	44.75		595.32	1.00		
		11.00		872.75	485.00		904.65		13.05	49.83
88.55 122.46	140.36 342.00	318.56 711.68	673.72 413.15	22.35 206.00	11.65 35.84		118.84 398.74	6.00 32.00	535.63 188.26	
	1,751.63	9.88	122.97	33.92	44.83	31.36	123.98		162.47	
		245.74	23.21	25.45	17.00	96.44	112.43	5.16		
.62		1.75	2.00	1,109.61			555.91	9.36	402.06	
	1,988.04	101.55	47.08	14.00	76.61		452.22			
69.58 74.39		195.22 19.26	151.36 130.26	11.52 94.19	50.24 4.60		395.86 358.40	145.29	523.49	
		717.39	21.95	22.06	85.85		1,008.48		107.55	
304.82	1,204.00		1,390.89	120.83	61.95	45.00	184.92	2.71		29
	55.55						406.71			
	763.60		257.08	67.00	454.47	96.25	188.12		324.03	
2,702.64	20,420.16	5,908.33	11,531.91	6,114.71	4,277.30	1,240.76	15,795.12	842.63	6,454.71	321.80

TABLE 7.—Expenditures from United States appropriations received under

Station	Amount of appropriation	Expenditures						
		Salaries	Labor	Postage and stationery	Freight and express	Heat, light, water, and power	Chemical supplies	Seeds, plants, and sundry supplies
Alabama.....	\$15,000	\$11,224.88	\$755.41	\$16.35	\$78.23	\$135.57	\$1,527.50	\$216.96
Arizona.....	15,000	9,688.08	2,755.93	45.02	34.79	.....	501.01	182.18
Arkansas.....	15,000	8,321.66	1,849.82	142.81	82.16	272.83	1,193.62	463.38
California.....	15,000	15,000.00	.....	.....	.....	.....	.....	.....
Colorado.....	15,000	15,000.00	.....	.....	.....	.....	.....	.....
Connecticut (State).....	7,500	7,500.00	.....	.....	.....	.....	.....	.....
Connecticut (Storrs).....	7,500	7,500.00	.....	.....	.....	.....	.....	.....
Delaware.....	15,000	11,131.00	2,826.81	3.85	9.97	.....	358.11	87.48
Florida.....	15,000	14,869.02	130.98	.....	.....	.....	.....	.....
Georgia.....	15,000	9,691.36	2,078.61	1.75	27.54	613.29	76.11	84.18
Hawaii.....	13,000	11,151.00	816.65	7.96	5.91	.....	418.52	11.10
Idaho.....	15,000	12,123.50	962.91	1.00	85.53	7.22	865.00	77.89
Illinois.....	15,000	10,460.74	4,539.26	.....	.....	.....	.....	.....
Indiana.....	15,000	12,914.50	731.40	25.02	4.27	.....	665.08	251.05
Iowa.....	15,000	15,000.00	.....	.....	.....	.....	.....	.....
Kansas.....	15,000	10,300.00	3,734.05	11.40	4.00	13.00	79.83	8.93
Kentucky.....	15,000	14,277.34	23.70	.....	.....	29.21	169.71	.....
Louisiana.....	15,000	10,118.33	1,549.84	12.04	72.45	.....	862.78	221.61
Maine.....	15,000	15,000.00	.....	.....	.....	.....	.....	.....
Maryland.....	15,000	13,896.08	879.00	23.88	.....	.....	167.13	23.76
Massachusetts.....	15,000	14,250.00	.....	.....	.....	.....	.....	.....
Michigan.....	15,000	15,000.00	.....	.....	.....	.....	.....	.....
Minnesota.....	15,000	14,979.45	.....	.....	.....	.....	.....	.....
Mississippi.....	15,000	10,588.37	3,292.08	34.74	18.60	63.36	237.17	452.53
Missouri.....	15,000	3,007.48	5,056.55	681.81	249.40	326.08	1,990.75	388.15
Montana.....	15,000	9,504.88	3,132.97	10.81	13.85	49.44	499.40	191.02
Nebraska.....	15,000	15,000.00	.....	.....	.....	.....	.....	.....
Nevada.....	15,000	8,547.65	4,690.82	131.02	18.54	.....	206.34	222.03
New Hampshire.....	15,000	11,683.66	1,169.04	12.12	20.20	.....	356.20	178.66
New Jersey.....	15,000	9,838.55	109.99	27.63	.....	498.09	1,148.36	311.20
New Mexico.....	15,000	8,997.95	2,558.79	61.93	192.75	300.51	955.31	171.37
New York (Cornell).....	13,500	11,468.20	1,221.20	.14	.....	.....	484.29	20.60
New York (State) ¹	1,500	1,410.00	.....	.....	.....	.....	20.93	.....
North Carolina.....	15,000	12,130.00	419.79	21.07	12.11	.....	833.94	87.21
North Dakota.....	15,000	14,569.59	333.00	.....	.....	.....	57.02	.....
Ohio.....	15,000	14,637.88	214.57	32.65	.....	.....	14.66	24.31
Oklahoma.....	15,000	8,881.67	2,445.97	51.80	6.04	1.50	1,204.35	397.87
Oregon.....	15,000	11,043.11	1,941.04	56.11	31.56	123.58	842.23	84.87
Pennsylvania.....	15,000	14,820.00	104.15	.....	2.88	.....	72.97	.....
Puerto Rico.....	10,000	2,816.67	2,528.64	16.52	1.10	.....	8.60	38.96
Rhode Island.....	15,000	9,755.49	2,684.37	39.50	16.00	343.85	223.03	62.50
South Carolina.....	15,000	10,399.92	2,132.75	223.38	9.32	283.68	159.83	131.84
South Dakota.....	15,000	8,250.83	3,661.22	20.46	118.97	35.20	619.57	298.50
Tennessee.....	15,000	12,589.27	1,322.62	7.03	35.67	41.11	344.67	47.08
Texas.....	15,000	10,998.00	2,410.39	18.50	24.17	.....	661.26	86.20
Utah.....	15,000	8,096.88	3,986.65	55.55	62.73	.....	1,042.26	239.91
Vermont.....	15,000	9,592.93	3,942.02	49.56	24.55	44.15	558.99	191.97
Virginia.....	15,000	9,193.74	3,686.44	.....	.....	116.88	230.15	38.05
Washington.....	15,000	13,206.75	910.46	40.05	.....	.....	609.33	53.70
West Virginia ²	15,000	10,430.00	2,519.73	9.00	.....	61.41	513.13	138.19
Wisconsin.....	15,000	11,083.89	3,550.12	.....	.....	.....	236.79	.....
Wyoming.....	15,000	11,661.20	1,268.00	34.73	22.91	.....	463.21	83.25
Total.....	743,000	573,601.39	84,927.74	1,927.19	1,286.20	3,359.96	21,479.14	5,568.49

¹ Including balance of appropriation from previous year \$275.83.² Including balance of appropriation from previous year \$845.27.

the act of Mar. 15, 1906 (Adamas Act), for the year ended June 30, 1935

Expenditures—Continued

Ferti- lizers	Feed- ing stuffs	Library	Tools, imple- ments, and ma- chinery	Furni- ture and fixtures	Scien- tific appara- tus	Live- stock	Travel expenses	Conti- nent ex- penses	Build- ings and land	Balance
\$12.25	\$29.62	\$0.59	\$9.80	\$122.66	\$509.53	-----	\$96.40	\$44.33	\$219.92	-----
101.31	-----	-----	128.88	356.16	160.70	-----	1,016.79	29.15	-----	-----
137.19	230.79	17.00	270.87	-----	945.69	-----	362.20	5.00	704.98	-----
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
-----	-----	17.46	1.70	84.19	206.00	-----	272.23	1.20	-----	-----
-----	1,917.51	-----	33.79	-----	52.27	\$311.14	7.25	-----	105.20	-----
-----	21.16	-----	-----	-----	567.70	-----	-----	-----	-----	-----
-----	143.39	-----	400.64	14.84	224.65	-----	20.90	21.12	51.41	-----
8.20	271.96	-----	5.21	-----	123.31	-----	-----	-----	-----	-----
-----	358.00	-----	-----	-----	287.45	42.00	-----	.50	160.84	-----
7.60	311.57	-----	.45	-----	428.08	71.51	-----	-----	-----	-----
-----	-----	-----	521.93	12.48	656.96	228.51	423.90	-----	-----	-----
-----	-----	-----	-----	-----	10.15	-----	-----	-----	750.00	-----
-----	-----	-----	-----	-----	20.55	-----	-----	-----	-----	-----
25.68	-----	-----	218.82	-----	61.58	2.62	-----	-----	4.45	-----
170.50	2,039.49	7.00	273.93	-----	379.10	127.25	46.60	-----	255.91	-----
3.75	11.20	12.37	149.81	29.75	280.80	-----	1,109.95	-----	-----	-----
-----	589.76	-----	32.66	-----	9.00	149.85	389.83	12.50	-----	-----
4.45	481.65	-----	4.96	130.31	601.64	-----	89.60	16.00	251.51	-----
-----	-----	425.80	127.06	53.35	1,608.66	-----	55.60	50.33	745.38	-----
154.56	-----	7.77	537.54	60.60	469.47	-----	265.25	-----	266.20	-----
-----	-----	-----	20.51	-----	285.06	-----	-----	-----	-----	-----
-----	58.20	-----	-----	-----	69.07	-----	-----	-----	-----	-----
-----	-----	3.20	34.94	-----	863.03	-----	574.65	-----	-----	-----
-----	75.93	-----	-----	-----	2.25	-----	-----	-----	-----	-----
-----	1,394.54	-----	90.45	11.75	301.99	-----	65.56	-----	146.51	-----
16.80	1.19	15.00	223.66	-----	462.39	-----	147.04	11.53	-----	-----
29.56	-----	-----	-----	128.25	20.00	-----	1,802.21	-----	-----	\$2,609.49
-----	1,386.00	79.16	26.36	3.60	332.08	4.50	5.38	-----	38.18	-----
-----	-----	94.31	171.65	96.83	238.98	-----	357.51	-----	700.00	-----
6.00	316.55	133.04	188.19	294.25	178.87	12.70	688.01	-----	177.64	-----
-----	-----	19.59	52.82	80.90	176.49	-----	216.66	-----	66.09	-----
-----	116.98	46.41	16.50	-----	487.47	25.00	-----	-----	109.12	-----
-----	-----	18.74	204.83	49.35	478.93	355.15	409.02	-----	-----	-----
5.32	-----	22.18	54.41	47.43	389.84	-----	54.56	-----	22.09	-----
-----	407.29	-----	255.37	2.62	877.14	-----	192.32	-----	-----	-----
-----	-----	1.20	-----	-----	71.10	-----	107.41	-----	-----	-----
-----	222.20	-----	21.56	-----	1,050.43	-----	34.35	-----	-----	-----
-----	129.20	-----	-----	-----	-----	-----	-----	-----	-----	-----
-----	604.20	-----	36.93	-----	63.69	48.00	685.53	-----	28.35	-----
683.17	11,118.38	920.82	4,116.23	1,579.32	13,952.10	1,378.23	9,496.71	191.66	4,803.78	2,609.49

TABLE 8.—Expenditures from United States appropriations received under the

Station	Amount of ap- propriation	Expenditures							
		Salaries	Labor	Publi- cations	Postage and station- ery	Freight and express	Heat, light, water, and power	Chemical supplies	Seeds, plants, and sundry supplies
Alabama.....	\$60,000	\$39,803.35	\$7,771.42	\$544.89	\$1,230.02	\$521.04	\$938.72	\$1,768.73	\$1,043.67
Arizona.....	60,000	39,534.99	7,179.93	1,604.18	179.47	261.17	693.71	3,338.16	511.71
Arkansas.....	60,000	36,034.54	4,435.58	3,108.19	821.61	89.21	182.62	2,037.67	862.76
California.....	60,000	58,984.80	1,015.20						
Colorado.....	60,000	45,853.06	6,562.85	821.21	248.75	73.24	376.59	657.68	286.98
Connecticut (State).....	30,000	21,852.25	4,969.05	8.25	371.29	24.06	207.62	761.96	285.59
Connecticut (Storrs).....	30,000	23,559.52	3,007.24	11.50	658.51	.93		180.31	
Delaware ¹	60,000	37,174.89	9,754.43	1,354.79	177.86	39.40	782.29	1,544.77	604.44
Florida.....	60,000	36,489.50	14,125.41	599.66	229.13	40.66	4.90	3,090.57	555.54
Georgia.....	60,000	37,367.17	8,532.01	1,125.02	322.75	222.42	2,923.94	719.63	338.24
Idaho.....	60,000	31,523.12	8,954.45	3,028.37	301.58	199.57	243.87	2,084.10	318.08
Illinois ²	60,000	30,234.40	10,716.00	5,360.07	1,123.19	184.05		369.23	940.68
Indiana.....	60,000	42,585.92	6,827.68	215.91	271.98	102.22		743.74	173.50
Iowa.....	60,000	55,032.48	2,340.99	1,426.94			7.94		178.49
Kansas.....	60,000	37,500.00	16,683.62	19.46	47.56			907.05	129.65
Kentucky.....	60,000	49,611.24	3,857.99	668.81	92.03	18.81	26.26	1,129.76	129.87
Louisiana.....	60,000	42,222.61	11,232.01	389.11	248.74	157.26	211.53	550.92	474.45
Maine.....	60,000	43,167.62	7,852.16	22.55	253.77	69.12	860.45	323.66	710.87
Maryland.....	60,000	44,115.88	4,014.43	609.95	169.93	67.21	53.67	2,828.31	562.31
Massachusetts.....	60,000	46,475.57	2,920.82	499.25	177.94	5.29		899.99	162.68
Michigan.....	60,000	45,593.16	6,765.95	2,657.55	399.37	17.20		514.32	203.64
Minnesota.....	60,000	47,079.11	1,981.48	983.78	125.82	171.96		784.43	1,516.53
Mississippi.....	60,000	37,621.68	10,822.11	106.25	1,037.87	126.23	2,584.67	1,037.77	1,204.63
Missouri.....	60,000	17,360.82	18,274.10	3,076.28	557.91	520.76	310.26	4,157.56	970.80
Montana.....	60,000	28,914.91	17,148.28	1,471.31	366.43	213.13	364.14	1,508.82	923.78
Nebraska.....	60,000	39,723.54	7,648.13	192.86	21.47	208.67	53.38	724.43	323.57
Nevada.....	60,000	38,041.25	2,752.51	668.10	1,312.49	270.75	230.62	674.57	2,407.79
New Hampshire.....	60,000	39,799.63	8,099.46	261.55	387.84	145.80	41.24	834.92	1,308.78
New Jersey.....	60,000	46,721.43	4,528.65	105.84	456.01	17.57	174.10	1,652.77	650.11
New Mexico.....	60,000	30,352.08	10,356.62	1,222.20	843.08	365.00	692.56	643.91	594.06
New York (Cornell).....	54,000	43,121.98	777.80		385.95	22.43		565.29	22.22
New York (State).....	6,000	4,215.00	1,200.00					53.90	20.94
North Carolina.....	60,000	40,290.35	6,043.63	279.32	290.86	107.43	108.20	590.63	447.10
North Dakota.....	60,000	37,176.48	7,480.20	1,322.82	219.55	15.86	129.20	486.66	97.97
Ohio.....	60,000	41,265.52	9,507.06	154.53	20.34		1,116.57	321.31	100.22
Oklahoma.....	60,000	29,448.08	15,745.23	2,098.24	437.82	59.46	32.60	1,684.02	1,088.43
Oregon.....	60,000	37,422.48	11,947.59	693.75	584.69	124.84	451.35	1,841.20	674.77
Pennsylvania.....	60,000	48,410.94	4,197.37	956.44	170.49	57.62	72.27	409.02	129.71
Rhode Island.....	60,000	41,822.88	9,738.46	527.80	342.99	22.95	500.68	757.58	144.30
South Carolina.....	60,000	35,637.37	10,412.60	1,533.36	563.07	55.65	322.68	1,110.83	452.41
South Dakota.....	60,000	29,511.97	13,524.63	2,160.58	1,510.23	122.56	164.51	1,612.57	713.38
Tennessee.....	60,000	43,912.11	6,286.80	373.76	226.01	348.62	133.81	1,034.62	565.08
Texas.....	60,000	29,284.25	17,888.16		721.87	144.59	43.56	2,036.83	192.81
Utah.....	60,000	30,882.17	15,624.87	1,531.94	943.31	170.36	71.10	1,003.92	969.33
Vermont.....	60,000	38,210.79	8,688.10	1,495.72	935.98	26.48	2,301.83	1,052.93	433.97
Virginia.....	60,000	40,092.12	12,461.09	835.03	156.39	27.29	14.20	226.38	147.96
Washington.....	60,000	39,274.90	10,237.97	1,429.69	360.58	26.07		1,431.57	547.95
West Virginia ³	60,000	39,290.43	7,841.78	2.00	214.42	464.36	249.52	1,542.20	272.56
Wisconsin.....	60,000	45,700.84	11,969.47					772.83	
Wyoming.....	60,000	31,869.81	10,110.63	1,514.99	226.06	540.87	229.52	1,903.95	423.36
Total.....	2,880,000	1,897,170.99	423,036.00	49,073.80	20,745.01	6,470.17	17,906.68	56,907.98	25,817.67

¹ Including balance of appropriation from previous year \$1,286.78.² Including balance of appropriation from previous year \$1,392.05.³ Including balance of appropriation from previous year \$57.11.

act of Feb. 24, 1925 (Purnell Act), for the fiscal year ended June 30, 1935

Expenditures—Continued

Fertilizers	Feeding stuffs	Library	Tools, implements, and machinery	Furniture and fixtures	Scientific apparatus	Livestock	Travel expenses	Contingent expenses	Buildings and land	Balance
\$86.74	\$1,938.16	\$220.20	\$322.47	\$206.60	\$2,639.42	\$267.00	\$328.76	\$139.89	\$228.92	-----
300.11	1,129.02	6.87	726.61	560.22	865.91	19.24	2,968.86	92.44	27.40	-----
17.50	203.31	247.29	564.75	519.48	4,259.74	-----	1,116.88	29.75	5,469.12	-----
17.50	408.71	41.31	752.49	40.75	1,441.35	102.00	1,828.29	105.28	381.96	-----
196.18	-----	-----	169.28	95.13	212.95	-----	562.72	16.98	266.69	-----
-----	-----	69.16	-----	218.37	190.66	-----	1,798.80	5.00	-----	-----
137.95	2,527.81	244.22	700.10	994.45	1,387.94	-----	1,958.46	179.75	436.45	-----
26.64	264.82	41.97	128.19	122.00	1,178.26	160.90	2,456.29	42.00	443.56	-----
-----	5,728.65	250.21	510.51	265.67	143.78	-----	1,227.10	19.00	303.90	-----
-----	4,532.01	183.14	1,335.75	445.47	3,801.05	81.00	2,212.23	136.33	619.88	-----
-----	583.15	123.39	1,626.35	1,933.23	2,687.88	327.40	2,886.30	367.39	537.29	-----
31.71	289.33	13.50	375.11	979.12	1,442.12	-----	5,846.92	47.74	53.50	-----
-----	-----	-----	42.75	-----	978.35	-----	-----	-----	-----	-----
-----	581.95	6.33	983.05	9.90	2,108.91	346.31	154.99	3.50	509.78	-----
-----	690.56	65.77	-----	26.55	2,478.99	-----	1,159.36	44.00	-----	-----
334.36	1,315.57	-----	425.53	42.70	388.58	253.50	1,558.46	14.66	180.01	-----
23.99	1,998.26	35.19	640.56	219.55	621.69	277.20	2,607.35	35.45	280.56	-----
788.01	-----	10.45	850.81	385.58	2,157.09	39.09	3,224.65	17.00	105.63	-----
10.50	191.22	54.14	14.09	256.56	775.48	197.29	1,347.96	11.22	6,000.00	-----
-----	339.31	85.90	142.38	352.90	67.70	-----	2,669.35	87.27	104.00	-----
-----	2,899.79	38.00	341.43	124.12	997.89	1,116.77	1,652.02	51.66	135.21	-----
198.00	705.55	69.35	1,533.90	581.83	306.52	43.00	830.24	257.11	933.29	-----
47.81	7,627.10	54.39	1,904.80	597.98	1,561.45	1,117.75	863.64	579.88	416.71	-----
144.74	621.71	64.37	1,448.90	220.43	2,313.92	500.00	3,498.25	24.46	252.42	-----
-----	5,568.98	9.50	123.40	718.24	2,086.91	434.40	1,967.67	9.40	185.45	-----
-----	3,219.87	164.76	1,411.95	1,341.73	499.78	589.00	2,585.20	79.75	3,749.88	-----
566.86	648.83	25.40	715.70	744.49	1,424.32	75.50	4,447.02	48.41	424.25	-----
26.50	308.83	210.84	785.16	537.50	1,836.37	51.33	1,791.84	63.64	81.51	-----
104.09	5,004.33	123.83	1,224.67	1,633.54	418.23	468.00	3,809.25	30.13	2,114.42	-----
-----	287.75	.50	303.49	1,359.38	5,827.15	-----	1,315.71	10.35	-----	-----
-----	-----	71.19	-----	-----	433.36	-----	5.61	-----	-----	-----
157.64	5,014.98	67.23	309.89	325.58	1,705.71	140.00	3,739.27	16.91	365.27	-----
-----	7,495.01	14.98	259.14	32.50	386.83	3,511.24	1,210.19	21.64	139.73	-----
-----	5,769.74	-----	343.10	-----	378.23	917.53	105.85	-----	-----	-----
-----	5,793.60	36.65	932.22	351.97	724.31	220.50	1,278.92	15.20	52.75	-----
13.60	274.05	40.58	1,302.86	482.94	366.37	14.00	3,655.43	2.00	107.50	-----
100.06	1,711.61	38.17	164.64	4.50	309.87	304.00	3,031.29	10.00	-----	-----
581.47	2,079.84	50.71	686.71	-----	813.66	3.00	723.47	1.50	1,202.00	-----
391.30	1,633.65	221.91	490.69	445.29	2,970.21	460.00	987.03	90.65	2,281.30	-----
-----	2,217.52	191.07	393.24	2,192.38	762.07	371.90	3,456.66	342.94	751.79	-----
105.09	412.43	379.04	2,053.77	744.07	487.72	5.00	1,159.40	125.58	1,667.09	-----
6.60	795.79	98.70	272.18	365.06	3,588.25	20.00	2,672.96	15.25	1,853.14	-----
6.61	1,292.51	261.01	534.86	1,091.09	338.41	729.99	3,751.98	24.50	772.04	-----
29.43	619.30	2.50	525.98	137.72	1,465.76	100.00	1,865.44	418.39	1,689.68	-----
-----	80.80	9.20	438.24	577.81	1,214.22	12.80	3,624.01	42.18	34.55	\$5.73
106.41	2,128.02	279.42	91.85	622.45	933.80	1,011.49	1,472.47	22.27	23.09	-----
271.83	1,441.85	18.57	1,031.14	274.53	1,509.22	845.86	3,685.62	13.18	1,030.93	-----
-----	446.86	-----	-----	-----	347.65	-----	582.35	180.00	-----	-----
-----	9,301.23	-----	142.85	22.49	867.69	310.30	2,419.81	-----	117.04	-----
4,829.23	98,123.37	4,240.91	30,057.54	23,203.85	66,703.13	15,384.29	100,102.33	3,891.63	36,329.69	5.73

TABLE 9.—Expenditures from supplementary funds received from within the States for the year ended June 30, 1935

State	Salaries	Labor	Publications	Postage and stationery	Freight and express	Heat, light, water, and power	Chemical supplies	Seeds, plants, and sundry supplies	Fertilizers	Feeding stuffs
Alabama.....	\$49,046.37	\$18,218.80	\$2,234.97	\$2,445.80	\$2,055.55	\$6,943.79	\$944.62	\$7,450.10	\$4,113.35	\$3,787.33
Alaska.....	3,021.67	2,184.53	-----	47.64	165.52	224.43	14.35	1,985.95	50.74	43.50
Arizona.....	40,137.06	14,250.27	3,751.11	1,909.60	242.31	1,576.73	1,802.27	2,691.43	196.94	526.33
Arkansas.....	35,955.84	13,407.90	3.22	1,754.17	1,031.48	3,542.66	2,989.47	2,724.52	1,010.42	3,719.03
California.....	308,097.74	149,105.85	19,206.05	17,541.86	6,139.65	19,296.05	17,541.86	35,083.73	7,016.75	43,854.66
Colorado.....	34,669.77	22,574.09	2,514.63	2,239.25	1,462.61	9,265.89	1,781.45	3,634.85	33.50	6,934.02
Connecticut (State).....	100,843.95	58,703.36	455.15	4,351.75	216.51	8,314.98	1,195.13	2,407.23	1,129.05	2,816.11
Connecticut (Storrs).....	18,326.35	12,822.64	252.94	1,354.82	417.19	5,502.10	1,829.61	503.90	479.60	2,177.77
Delaware.....	4,000.00	10,939.75	-----	4,752.01	326.86	2,997.79	1,119.03	3,290.71	461.69	4,319.42
Florida.....	155,737.67	69,341.87	6,369.34	4,970.90	2,327.51	11,500.75	3,719.03	9,942.47	7,093.40	14,879.74
Georgia.....	2,242.02	636.59	636.59	309.02	1,233.41	3,726.62	182.93	9,438.03	224.85	957.77
Hawaii.....	12,066.68	200.93	200.93	103.57	1,253.75	-----	-----	-----	-----	-----
Idaho.....	9,494.37	4,496.35	-----	538.14	117.26	1,043.71	706.04	1,379.25	-----	7,360.10
Illinois.....	206,757.94	99,272.52	9,085.76	4,038.94	2,531.92	10,873.00	13,307.24	25,220.24	4,903.33	2,832.55
Indiana.....	186,019.33	98,916.59	5,036.85	29,253.05	2,531.92	10,873.00	19,284.41	7,358.16	7,005.42	31,528.30
Iowa.....	129,544.82	39,274.02	15,508.91	4,662.09	1,925.27	2,111.21	6,386.39	11,080.40	465.83	36,604.05
Kansas.....	32,439.34	51,570.30	1,144.62	3,004.32	1,901.39	5,241.20	7,990.59	4,844.64	68.00	5,552.27
Kentucky.....	122,696.88	42,987.68	534.46	3,712.31	1,189.41	5,242.29	2,946.65	14,992.59	706.68	8,533.97
Louisiana.....	49,857.09	22,384.90	33.97	1,530.84	887.64	2,303.92	1,715.14	2,530.34	887.86	1,607.39
Maine.....	17,151.93	14,995.35	12.00	511.97	383.36	3,798.79	1,547.72	1,691.80	1,770.32	992.32
Maryland.....	30,389.69	18,811.51	509.26	1,626.21	1,268.52	3,078.25	976.05	4,719.73	1,015.79	8,453.94
Massachusetts.....	105,683.65	31,758.32	2,638.59	2,308.00	1,070.81	1,474.77	3,713.44	3,499.02	1,257.96	4,075.13
Michigan.....	31,698.39	62,803.22	14,289.90	2,340.51	910.82	3,397.77	7,071.30	9,738.48	780.14	9,179.32
Minnesota.....	215,692.47	86,276.99	632.14	8,256.32	2,645.44	17,142.69	8,021.44	15,570.47	483.09	19,488.05
Mississippi.....	41,389.40	29,277.19	735.65	2,736.94	1,606.44	4,910.79	9,091.49	11,835.11	336.46	2,246.25
Missouri.....	31,196.83	23,064.71	1,931.15	2,604.80	609.61	1,189.92	4,918.53	5,053.87	28.32	4,278.60
Montana.....	58,070.80	18,379.34	2,752.88	2,733.79	1,003.59	3,890.75	6,414.50	16,817.13	13.07	13,071.56
Nebraska.....	62,235.56	21,254.20	2,462.09	2,332.81	768.97	6,153.46	6,722.17	1,664.35	5,387.58	33,792.41
Nevada.....	620.80	165.41	149.16	59.43	93.19	1,897.81	40.05	259.92	-----	739.70
New Hampshire.....	16,697.76	4,165.59	111.17	1,352.29	108.70	75.69	806.51	731.99	-----	333.31
New Jersey.....	313,163.94	15,360.36	6,145.76	10,586.24	1,047.07	16,823.51	8,897.04	1,146.29	1,290.91	27,049.20
New Mexico.....	6,373.46	3,251.40	369.55	10,224.49	133.67	1,277.34	8,627.03	1,130.48	-----	2,483.03
New York (Cornell).....	344,178.02	68,000.39	13,846.88	10,111.04	1,306.32	23,679.02	17,395.17	17,091.25	3,325.97	12,167.47
New York (State).....	137,616.59	34,899.71	7,321.91	3,700.54	879.39	13,249.74	4,797.49	2,286.54	-----	4,403.14
North Carolina.....	34,580.62	32,864.33	2,377.47	2,739.41	1,197.31	2,055.19	1,357.48	3,870.66	4,889.06	11,172.20
North Dakota.....	23,084.89	22,187.09	1,228.97	1,343.60	663.29	4,585.57	2,630.79	1,700.58	29.50	9,685.25
Ohio.....	200,133.18	72,120.08	25,894.21	4,830.30	1,491.56	23,262.55	2,380.38	18,524.29	551.19	24,620.97
Oklahoma.....	61,820.82	9,917.18	2,564.73	2,096.24	573.64	1,424.29	1,682.02	9,306.03	-----	6,369.33
Oregon.....	64,521.62	50,355.97	1,783.63	2,743.07	1,217.30	6,817.28	4,086.64	1,698.07	494.51	9,353.59
Pennsylvania.....	89,416.37	29,057.81	2,491.90	3,831.11	1,277.07	2,170.44	6,045.50	7,698.34	1,489.56	1,662.76
Porto Rico.....	70,350.45	19,294.45	700.01	2,265.22	120.73	329.07	1,321.97	1,535.01	1,705.77	1,662.76
Rhode Island.....	234.16	28.10	339.04	2,652.04	114.69	-----	335.55	1,411.82	18.00	927.40
South Carolina.....	24,276.31	31,186.03	754.53	1,264.51	902.58	1,103.43	12,472.64	5,044.75	5,666.59	12,924.81

South Dakota.....	10,202.00	3,555.63	760.00	489.11	334.61	280.33	85.36	868.26	123.26	5,201.66
Tennessee.....	14,376.05	5,783.91	300.77	612.34	418.36	859.17	3.90	1,603.07	1,003.07	2,968.84
Texas.....	204,519.30	66,823.31	7,268.40	9,368.31	2,451.26	5,750.05	7,825.74	35,596.61	29,644.73	29,644.73
Utah.....	11,617.67	13,277.28	1,532.92	2,288.44	449.36	10,428.56	2,220.40	2,014.14	1,459.64	1,459.64
Vermont.....	6,610.00	6,041.76	992.20	352.56	47.99	489.57	201.84	158.75	165.40	5,451.01
Virginia.....	50,094.88	12,822.37	1,166.55	863.75	499.71	1,194.87	1,341.35	1,772.27	1,045.77	3,717.88
Washington.....	67,444.70	69,674.40	1,408.25	3,141.15	559.79	3,029.00	4,450.68	8,420.79	436.52	7,198.48
West Virginia.....	25,845.00	20,280.57	822.26	1,302.75	354.88	5,141.39	4,990.72	5,087.48	872.22	4,390.87
Wisconsin.....	164,118.44	65,647.37	8,205.92	7,385.33	2,461.78	8,616.22	7,793.63	14,770.66	2,872.07	18,463.32
Wyoming.....	21,466.20	8,586.48	-----	268.73	576.64	899.64	-----	4,807.91	-----	5,187.94
Total.....	4,246,826.84	1,708,992.03	178,262.09	183,742.43	52,917.95	272,435.79	204,638.21	362,663.46	71,873.39	501,853.81

TABLE 9.—Expenditures from supplementary funds received from within the States for the year ended June 30, 1935—Continued

State	Library	Tools, imple- ments, and machinery	Furniture and fix- tures	Scientific apparatus	Livestock	Travel expenses	Contingent expenses	Buildings and land	Balance	Total
Alabama.....	\$153.15	\$1,841.78	\$1,147.57	\$135.03	\$2,237.50	\$4,873.89	\$5,295.45	\$1,585.12	\$62,598.66	\$176,508.83
Alaska.....		195.29		1.80		208.80		324.88	729.03	9,198.43
Arizona.....		696.64	2,063.18		75.00	4,244.77	1,010.51	8,694.52	2,947.08	86,878.75
Arkansas.....	692.50	4,079.55	2,466.59	1,433.04	632.76	1,610.03	1,812.57	549.13		75,168.93
California.....	4,385.46	23,683.84	7,893.62	12,279.31	15,737.65	35,083.73	15,787.68	61,306.53	17,823.27	877,093.22
Colorado.....	227.29	6,776.70	607.51	1,944.94	1,178.40	4,844.37	15,957.67	4,712.77	37,670.80	140,027.51
Connecticut (State).....	1,705.11	6,941.45	1,059.61	674.92		12,590.89	2,473.07	3,606.26		216,214.07
Connecticut (Storrs).....	934.25	74.90	174.90	661.35	101.40	1,111.86	126.24		320.58	
Delaware.....	52.22	1,431.70	28.70	133.98	475.00	2,737.17	308.31	1,064.95	4,757.88	42,491.10
Florida.....	2,222.47	11,405.97	2,576.41	2,427.64	1,550.77	11,867.37	788.73	18,083.62	20,948.61	35,938.20
Georgia.....	895.31		237.08	169.34	96.84	1,701.36	790.58	7,544.44	6,211.03	37,644.99
Hawaii.....	680.09				490.84	103.64	1,556.27	44.56		24,066.95
Idaho.....	18.27	1,833.54	13.55	432.32	100.25	776.01	2,103.75	1,043.51	820.08	27,860.86
Illinois.....	1,050.12	6,302.71	1,838.02	3,150.12	3,938.01	8,271.82	6,338.97			425,044.04
Indiana.....	1,984.95	10,023.35	4,796.41	4,548.23	1,233.73	20,765.90	6,993.36	40,612.51	240,162.26	734,003.48
Iowa.....	151.98	2,123.81	268.29	1,393.59	2,615.37	10,298.31	1,100.67	1,321.96	12,246.76	246,891.95
Kansas.....	85.67	9,937.27	992.62	3,704.80	1,629.22	4,517.77	357.62	5,511.09	19,804.72	170,357.65
Kentucky.....	1,525.72	2,243.12	828.67	2,960.57	3,213.69	9,472.44	4,165.43	21,802.33	2,320.55	252,075.44
Louisiana.....	53.50	3,727.17	709.88	1,338.88	675.98	5,079.13	1,047.18		4,072.14	50,468.95
Maine.....	157.14	2,227.29	471.88	1,101.37	668.90	2,937.44	322.07	1,778.68		52,520.33
Maryland.....	428.75	1,464.99	430.16	318.63	279.55	1,094.03	686.83	2,942.63	6,005.11	84,590.63
Massachusetts.....	689.10	2,396.91	1,388.16	2,044.21	696.12	5,541.42	388.92	751.91	62,153.29	232,894.72
Michigan.....	1,228.39	5,688.96	747.65	2,796.99	2,483.39	10,541.42	1,647.05	2,731.96		271,345.14
Minnesota.....	1,296.52	7,762.47	1,833.53	1,589.81	2,483.39	6,847.92	6,264.59	21,343.72		419,462.61
Mississippi.....	128.95	11,985.79	716.51	231.50	10,967.60	1,867.08	1,053.48	18,020.01	22,004.84	166,081.47
Missouri.....	107.33	4,055.77	2,561.97	2,162.06	1,931.91	1,665.87	494.10	5,804.58	33,956.25	128,094.52
Montana.....	63.82	5,425.84	883.69	237.93	914.00	3,842.56	91.46	1,788.64	39,617.74	139,617.74
Nebraska.....	270.91	1,927.20	3,216.67	4,178.32	8,194.39	2,132.21	1,171.77	4,732.75	8,977.15	168,527.82
Nevada.....	490.57		203.50	52.62		687.20	1,348.51	1,651.46	3,506.61	11,996.03
New Hampshire.....	117.28	9,614.45	246.19	77.74	172.94	6,570.47	1,291.54	6,498.40	25,930.04	463,723.80
New Jersey.....	935.30		567.12	1,037.30	674.50	13,468.56	16,972.03	4,514.71	13,423.87	463,018.16
New Mexico.....	326.38		34.38			213.32	71.76		39,839.64	56,249.32
New York (Cornell).....	2,603.11	13,287.71	3,070.46	18,966.31	1,783.47	22,214.30	2,840.39	4,438.44		580,305.74
New York (State).....	1,241.05	7,467.29	314.35			3,467.90	50.00	11,901.91	3,060.55	253,556.75
North Carolina.....	112.05	2,100.86	785.44	114.30	3,014.55	9,039.08	4,378.34	5,193.95		124,912.85
North Dakota.....	269.08	2,184.23	544.93	336.76	811.43	2,400.55	2,902.54	2,889.97	5,939.71	84,418.64
Ohio.....	925.67	2,904.77	597.84	683.93	3,763.45	6,890.89	8,913.18	23,936.82	381,989.59	804,404.55
Oklahoma.....	1,036.16	1,498.01	299.37	296.03	7,139.01	3,810.09	5,087.08	18,067.04	18,067.04	205,930.39
Oregon.....	260.41	6,719.28	1,312.41	1,434.61	4,468.22	4,875.42	3,133.31	5,653.36	36,006.22	309,434.92
Pennsylvania.....	465.22	2,814.01	814.37	1,404.53	1,755.03	7,451.42			3,495.86	167,130.92
Puerto Rico.....	322.56	1,106.89	1,405.49	968.87	267.88	1,422.72	13.79	1,846.19	2,847.05	111,328.25

Rhode Island.....	38.94	816.94	5.64	112.34	35.00	559.50	45.31	302.34	1,018.41	7,897.70
South Carolina.....	229.43	7,708.37	2,165.38	6,724.01	1,499.44	2,611.84	23.90	3,398.13	12,632.41	132,589.09
South Dakota.....	18.25	7,469.47	124.55	184.50	3,238.23	1,161.31	53.87	1,109.30	11,081.30	39,217.74
Tennessee.....	316.28	2,821.84	91.92	4.07	233.95	576.89	1,215.50	4,235.62	-----	36,545.74
Texas.....	1,381.11	5,877.63	3,209.09	1,688.81	8,031.24	22,903.46	28,517.61	13,748.57	77,314.58	531,425.81
Utah.....	422.09	2,196.73	783.45	1,443.16	117.20	2,712.17	558.69	6,030.86	9,848.45	66,656.61
Vermont.....	48.50	40.56	7.15	145.25	-----	1,921.53	103.12	28.27	711.12	23,351.18
Virginia.....	871.63	1,733.31	289.13	1,023.29	370.53	5,240.44	546.19	2,108.68	2,194.71	88,912.31
Washington.....	692.55	1,797.83	725.57	2,456.98	1,023.38	19,279.85	454.91	4,692.86	-----	195,857.69
West Virginia.....	10.74	4,783.98	94.18	519.94	1,022.70	899.09	950.11	1,747.79	6,271.17	81,387.84
Wisconsin.....	1,641.18	9,847.11	2,872.07	4,923.55	6,154.44	14,360.36	5,333.85	27,900.13	36,926.66	410,236.09
Wyoming.....	-----	5,198.86	-----	-----	729.54	939.62	-----	10,351.32	61,030.65	120,043.53
Total.....	35,964.51	232,210.08	58,353.86	95,859.96	111,388.18	329,879.98	149,135.10	389,453.58	1,319,674.73	10,506,125.98

TABLE 10.—Disbursements from the United States Treasury to the States and Territories for agricultural experiment stations under the acts of Congress approved Mar. 2, 1887, Mar. 16, 1906, Feb. 24, 1925, May 16, 1928, and Feb. 28, 1929

State or Territory	Hatch Act		Adams Act		Purnell Act	
	1888-1934	1935	1906-34	1935	1926-34	1935
Alabama.....	\$703,946.42	\$15,000.00	\$401,619.89	\$15,000.00	\$440,000.00	\$60,000.00
Alaska.....	45,000.00	15,000.00				
Arizona.....	669,803.10	15,000.00	404,955.61	15,000.00	440,000.00	60,000.00
Arkansas.....	703,139.12	15,000.00	404,990.00	15,000.00	440,000.00	60,000.00
California.....	705,000.00	15,000.00	404,926.84	15,000.00	440,000.00	60,000.00
Colorado.....	704,718.82	15,000.00	403,638.93	15,000.00	440,000.00	60,000.00
Connecticut.....	705,000.00	15,000.00	405,000.00	15,000.00	440,000.00	60,000.00
Dakota Territory.....	56,250.00					
Delaware.....	703,382.87	15,000.00	400,475.12	15,000.00	438,210.79	58,713.22
Florida.....	704,966.04	15,000.00	404,996.06	15,000.00	436,523.74	60,000.00
Georgia.....	700,593.43	15,000.00	392,092.87	15,000.00	440,000.00	60,000.00
Hawaii.....	74,919.17	15,000.00	31,951.14	13,000.00		
Idaho.....	629,324.13	15,000.00	400,842.22	15,000.00	440,000.00	60,000.00
Illinois.....	704,468.23	15,000.00	404,794.91	15,000.00	438,837.76	58,607.95
Indiana.....	704,901.19	15,000.00	405,000.00	15,000.00	440,000.00	60,000.00
Iowa.....	705,000.00	15,000.00	405,000.00	15,000.00	437,965.17	60,000.00
Kansas.....	704,995.00	15,000.00	405,000.00	15,000.00	440,000.00	60,000.00
Kentucky.....	704,996.57	15,000.00	405,000.00	15,000.00	440,000.00	60,000.00
Louisiana.....	705,000.00	15,000.00	405,000.00	15,000.00	440,000.00	60,000.00
Maine.....	704,959.62	15,000.00	405,000.00	15,000.00	440,000.00	60,000.00
Maryland.....	704,967.40	15,000.00	404,236.48	15,000.00	440,000.00	60,000.00
Massachusetts.....	704,617.70	15,000.00	405,000.00	15,000.00	440,000.00	60,000.00
Michigan.....	704,676.10	15,000.00	401,341.20	15,000.00	440,000.00	60,000.00
Minnesota.....	704,917.78	15,000.00	404,345.00	15,000.00	440,000.00	60,000.00
Mississippi.....	705,000.00	15,000.00	405,000.00	15,000.00	440,000.00	60,000.00
Missouri.....	700,097.24	15,000.00	404,999.90	15,000.00	440,000.00	60,000.00
Montana.....	615,000.00	15,000.00	402,417.04	15,000.00	440,000.00	60,000.00
Nebraska.....	704,932.16	15,000.00	405,000.00	15,000.00	440,000.00	60,000.00
Nevada.....	704,214.32	15,000.00	403,180.28	15,000.00	440,000.00	60,000.00
New Hampshire.....	705,000.00	15,000.00	405,000.00	15,000.00	440,000.00	60,000.00
New Jersey.....	704,949.97	15,000.00	404,392.06	15,000.00	440,000.00	60,000.00
New Mexico.....	669,509.05	15,000.00	405,000.00	15,000.00	440,000.00	60,000.00
New York.....	704,757.18	15,000.00	404,463.01	14,724.17	440,000.00	60,000.00
North Carolina.....	705,000.00	15,000.00	390,000.00	15,000.00	440,000.00	60,000.00
North Dakota.....	646,502.26	15,000.00	404,638.85	15,000.00	440,000.00	60,000.00
Ohio.....	705,000.00	15,000.00	403,514.02	15,000.00	440,000.00	60,000.00
Oklahoma.....	629,002.16	15,000.00	384,535.19	15,000.00	440,000.00	60,000.00
Oregon.....	690,156.64	15,000.00	400,000.00	15,000.00	440,000.00	60,000.00
Pennsylvania.....	704,967.43	15,000.00	404,995.41	15,000.00	440,000.00	60,000.00
Puerto Rico.....		15,000.00		10,000.00		
Rhode Island.....	705,000.00	15,000.00	399,520.20	15,000.00	440,000.00	60,000.00
South Carolina.....	704,542.15	15,000.00	403,460.12	15,000.00	440,000.00	60,000.00
South Dakota.....	648,250.00	15,000.00	400,000.00	15,000.00	440,000.00	60,000.00
Tennessee.....	705,000.00	15,000.00	405,000.00	15,000.00	440,000.00	60,000.00
Texas.....	705,000.00	15,000.00	402,592.26	15,000.00	440,000.00	60,000.00
Utah.....	570,000.00	15,000.00	404,821.94	15,000.00	440,000.00	60,000.00
Vermont.....	705,000.00	15,000.00	405,000.00	15,000.00	440,000.00	60,000.00
Virginia.....	702,824.12	15,000.00	404,949.61	15,000.00	440,000.00	60,000.00
Washington.....	642,102.65	15,000.00	401,080.11	15,000.00	440,000.00	60,000.00
West Virginia.....	704,960.08	14,835.74	402,859.12	14,154.73	440,000.00	59,942.89
Wisconsin.....	705,000.00	15,000.00	405,000.00	15,000.00	440,000.00	60,000.00
Wyoming.....	690,000.00	15,000.00	405,000.00	15,000.00	440,000.00	60,000.00
Total.....	33,341,350.10	764,835.74	19,371,534.79	741,878.90	21,111,537.46	2,877,264.06